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The Effects of Group Size on Achievement and Attitude Using Interactive Videodisc Courseware

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled

The Effects of Group Size on Achievement and Attitude
Using Interactive Videodisc Courseware

submitted by Marvin Lynn Clark in partial fulfillment of the requirements for the degree of Master of Education in Educational Psychology.

[redacted]

Date September 29, 1988

reduced perceptions regarding the value of IVD courseware, less anxiety reduction, and lower familiarity toward IVD courseware. The use of cooperative, interactive groups in CAI and IVD must address the learning variable of optimum group size as a significant contributor to creating an ideal learning environment.

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TABLE OF CONTENTS

ABSTRACT..... v

ACKNOWLEDGMENTS..... vii

TABLE OF CONTENTS..... viii

LIST OF TABLES..... x

LIST OF FIGURES..... xi

CHAPTER I THE PROBLEM

Introduction..... 1

Statement of the problem..... 9

Purpose of the study..... 11

Hypotheses..... 12

Significance of the study 13

Limitations and delimitations..... 14

Definitions and terminology..... 16

CHAPTER II LITERATURE REVIEW

Introduction..... 20

Summary review of Computer-assisted instruction..... 21

Videodiscs in corporate training..... 25

Videodiscs in military training..... 27

Videodiscs in educational institutions..... 28

Attitude..... 34

Studies involving student interaction..... 36

CHAPTER III METHODS

Population of study..... 42

Description of the courseware..... 43

Research design..... 45

Achievement instruments..... 46

Attitude instruments..... 47

Procedure..... 48

CHAPTER IV RESULTS

Hypotheses 1 through 4 Achievement 50

Hypothesis 5 Productivity 54

Hypothesis 6 Attitude..... 56

Hypothesis 7 Completion time..... 67

Subject comments 68

CHAPTER V DISCUSSION

Summary of results..... 71

Analysis of results: Attitudes..... 73

Analysis of results: Achievement..... 75

Analysis of results: Time for completion..... 78

Practical Implications..... 78

Casual observations..... 79

Suggestions for future research..... 80

BIBLIOGRAPHY..... 83

APPENDIX A Pretest/Posttest..... 91

APPENDIX B Opinionnaire..... 94

APPENDIX C Directions / module map..... 96

APPENDIX D Student comments..... 99

APPENDIX E Videodisc contents..... 102

APPENDIX F Release form..... 103

LIST OF TABLES

Table 1. Achievement data 51

Table 2. Two Way ANOVA with Repeated Measures..... 51

Table 3. Significant Differences in Achievement..... 51

Table 4. Productivity Ratio versus group size..... 54

Table 5. Two-way ANOVA for Productivity..... 54

Table 6. Significant Differences in Productivity..... 54

Table 7. Changes in Evaluation of IVD versus group size..... 56

Table 8. Two-way ANOVA for changes in Evaluation..... 57

Table 9. Significant differences in Evaluation..... 59

Table 10. Changes in Anxiety toward IVD versus group size..... 59

Table 11. Two-way ANOVA for changes in Anxiety..... 61

Table 12. Significant Differences in Anxiety..... 61

Table 13. Change in Familiarity toward IVD 62

Table 14. Two-way ANOVA for Changes in Familiarity..... 62

Table 15. Significant Differences in Familiarity Scale..... 65

Table 16. Completion time for IVD Courseware..... 66

Table 17. One-way ANOVA for Completion Time..... 66

Table 18. Significant Differences in Completion Time..... 67

Table 19. Compiled Student Perceptions of IVD Courseware..... 68

LIST OF FIGURES

Figure 1. Achievement: repeated measures..... 52

Figure 2. Productivity: Posttest/retention test..... 55

Figure 3. Changes in Evaluation after IVD..... 58

Figure 4. Changes in Anxiety after IVD..... 60

Figure 5. Changes in Familiarity after IVD..... 63

Figure 6. Attitude changes after IVD..... 64

CHAPTER ONE

THE PROBLEM

Introduction

Videodisc technology carries great promise for coping with current and future educational problems and has provided advancements in individualized instruction in specialized subject areas where traditional methods have been relatively ineffective. Intelligent videodisc (IVD) instruction combines the instructional strength of books, motion pictures, television and computers (Heuston, 1977).

Videodisc technology has generated considerable enthusiasm as evidenced by the following statement of Buckminster Fuller. "Videodisc technology will have more impact on our society than the computer has had to date." (Clark, 1984).

Many practitioners in education have been quick to adopt this medium and, those enamored with interactive videodisc, have described it as "the ultimate educational tool" (Currier, 1983), the "state-of-the-art teaching machine" (Levin, 1983), and as an "omnibus" medium (Nugent, 1979; Wood, 1979). The initial, enthusiastic claims regarding IVD technology have been supplanted by objective, critical analyses as indicated by remarks of Jonassen (1985) who described IVD as a "medium in search of design", and by Braden (1985) who suggests that the educational potential of IVD is being oversold and that the hardware technology is ahead of the instructional design technology to support it. Braden (1985) challenges instructional designers to produce courseware which is efficient in terms of learner's

achievement or teacher's tasks and to use the instructional advantages offered by IVD.

Reflective, optical (laser) videodiscs store large amounts of textual or video information. The information is digitally-encoded as microscopic pits on an aluminum, light relective layer covered by a protective layer of mylar plastic. The digitized information is read by a laser as the disc spins in a specially-designed player. Since there is no direct contact between the information and the pick-up device, there is no wear and the source signal does not deteriorate with time. Optical videodiscs are read-only devices and can exist in two different formats.

The 12 inch diameter, constant angular velocity (CAV) videodisc, contains 54,000 tracks, or frames, per side which are read by a pick-up laser at the rate of 30 frames per second. This disc could hold 54,000 individual pictures or 30 minutes of motion or any combination of motion and still images. Each revolution of the disc creates one picture (frame) on the video monitor. Textual information, transparencies, 35 mm slides, microfilm, motion pictures, videotape, schematic diagrams, etc., can be incorporated onto a videodisc. The disc has three separate tracks that could contain a computer program plus stereophonic sound, or two languages or two different difficulty levels of instruction. The CAV disc, when played in an industrial or educational videodisc player, is capable of very rapid, random access to individual frames and the video information can be displayed as still images or as motion sequences in slow

motion, regular speed or at three times normal speed in forward and reverse directions.

The advantages of a videodisc include an indestructible medium which has a tremenduous storage volume coupled with rapid random access capability to individual frames. This inherent power of the videodisc prompted Leveridge (1979) to state that "the videodisc represents the most significant innovation in educational technology since the invention of movable type by Gutenberg some 500 years ago." Even greater instructional power results when the audio-visual capabilities of videodisc are combined with the processing power of the computer. This combination has spawned the interactive (and intelligent) videodisc system (IVDS). Reigeluth and Garfield (1984) define the intelligent videodisc system (IVDS) as "videodisc players interfaced with an external microprocessor or minicomputer". Intelligent videodiscs can incorporate all existing instructional media such as print, audiovisual displays, and computer-assisted instruction into one medium.

All videodisc player operation can be controlled by an external microcomputer via an interface device. The 'intelligence' of the IVD system resides in the external computer and is stored on an eraseable or modifiable medium such as a floppy disk. The external intelligence provides the following capabilities:

1. to display textual information in the form of tutorial information, instructions to the student, questions, feedback, etc. on the computer monitor;
2. to evaluate and analyse student responses;

3. to provide appropriate branching for tutorial and remediation dependent upon the answer, evaluation and analysis; and

4. to provide records of student performance and status.

Most persons who watch the output from an optical videodisc are impressed by its video and audio qualities and capabilities (Hon, 1983). Surely, this is the medium that Marshall McLuhan must have been talking about when he stated "the medium is the message" (McLuhan, 1964, p.23). However, as with many new technologies, Smellie (1979) notes the refinement of the hardware often precedes the development of significant amounts of software. Pomeroy (1985) believes that the videodisc has been slow in developing its potential as an influential force in medical education as a result of the very few medical videodiscs available for public purchase. Indeed, Nugent (1985) describes videodisc development as a "phantom industry" with videodisc developers producing a limited number of proprietary discs for in-house, computer-based training, or for research and development purposes. The high cost of producing a videodisc contributes to the relative lack of suitable, educational videodiscs available to the public domain (Braden, 1985; Nugent, 1985).

The past three decades has witnessed the field of education evaluating the capability of many technological devices to facillitate learning. During this period, technophobes and technophiles alike have had numerous opportunities to resist technology or to embrace the latest technology, respectively. Since the introduction of Skinner's teaching machines (Skinner, 1958), new techniques and technologies have been evaluated. These instructional audiovisual media include

television and videotape (reviewed by Clark, 1983; Gropper, 1967), computer-assisted instruction (reviewed by Robyler, 1985; Kearsley, 1983), and currently, to the interactive or intelligent videodisc-based instructional systems (IVDS) (reviewed by Bosco, 1986).

The literature review (Chapter Two) describes videodisc systems and studies which evaluate the efficacy of interactive, videodisc-based instruction. Bosco (1986), in a comprehensive review of controlled studies evaluating IVD courseware, concluded that IVD was a highly-effective, instructional medium. Leveridge (1979) suggests that the combination of videodisc and microcomputer has new and exciting implications for educators as he stated:

> We know the power of audiovisual education to show what can best be learned by seeing and hearing. We know the value of interactive programs-thanks to automation by computer. But it is only through actual participation that one can fully appreciate the impact when both media are combined to deliver computer-assisted audiovisual education. It does not seem possible for words or pictures to communicate the excitement that this process generates. Even bystanders, though impressed, fail to appreciate the full flavor of the experience that the participant enjoys. And it is the videodisc that makes integration of the two media practical. By making audiovisual communication interactive, the videodisc has created a new dimension in teaching and testing. (p. 18)

Bork, Luehrmann, and Schnieder (1977) captured a similar mood as they wrote:

> An important moment is occurring, the moment when the computer plus powerful associated audiovisual capabilities can have a major effect upon education at all levels...It is realized that hardware alone is not sufficient but that hardware sales will be driven by the availability of well-tested, effective course materials. (p. 3)

Wisely, their enthusiasm was tempered with a caveat to prevent educators from assuming that mere usage of these technologies will, automatically, be superior to traditional methods of instruction. The warning is aimed, specifically, at reducing the tendency of courseware developers to rely solely upon the affective component supplied by television. The novelty of the television component of IVD cannot mask inadequacies in instructional design (Jonassen, 1985). Hofmeister (1982) urges that educational researchers exercise caution when evaluating a new medium. A simplistic comparison of similar curricula presented using traditional methods and the "new" medium may force one to focus upon the hardware rather than the effectiveness of the instruction. It is more important to stress the importance of the suitability of the new medium to the characteristics of the curriculum and of the learner. Lindsey (1984) advised developers to use the affective component of television to enhance and supplement a cognitive or a psychomotor instructional intent. Cambre (1984) supports the arguments of Bork, et al., (1977) that developers must

shift their focus from hardware to effective programming. However, before we dismiss the importance of the hardware, let us remember the advantages of videodisc as summarized by Levin (1983) as he stated:

> What assures the future of the disc is the greater information density that is possible, the better durability, the better picture and sound quality, the improved stability of the single frame image, the frame-by-frame forward or reverse capabilities and, most importantly, the rapid single frame access that allows a disc to be instructionally programmed or computer driven. (p. 12)

North (1984) suggested that an interactive videodisc is effective because its inherent instructional design succeeds in capturing and sustaining a users interest and transforms the user from a passive observer to an active learner. Anandam and Kelly (1981) reiterate that interactive video changes the student from a passive observer to an active participant. Bosco (1984) suggests that the motor responses, as in the case of pushing buttons/keys, are only a trivial component of the higher level cognitive processes as the learner actively processes and integrates the information.

Cohen (1984) and Huntley (1985) have documented recurrent deficiencies of poorly designed interactive video courseware. The criticisms include the mind-numbing, 'talking torsos' that engender passive watching, 'interaction' in the form of key pressing to control the pace of the expository learning, and branching that loops back to review sequences under the guise of remediation. Bork (1982) has

stressed the importance of the quality of the student-machine interaction and not just the quantity of the interaction. Cohen (1984) has written extensively on the need for feedback in interactive learning and has offered pragmatic guidelines for the instructional design of IVD courseware. The rapid random access capabilities of videodiscs coupled with voluminous storage capabilities creates the potential to allow for the realization of specific, and individualized, remedial feedback. Taken together, Bork has asked designers to consider the quality of interaction and Cohen has asked designers to optimize the role of feedback in interactive learning. Inherent to all these comments are the underlying requirements for rigorous formative evaluations in the instructional design process (Braden, 1985).

Kearsley, Hunter, and Seidel (1983) conducted an extensive review of CAI from 1959-1982 and concluded that CAI has witnessed the use of intuition as the most commonly-used guide in the development of courseware. Intuition was used by default as a result of the relative dearth of knowledge concerning the role of instructional variables in the learning process. Often, educators do not know how to use these variables in a precise and predictable way. The predominant mode of adapting to individual differences has been the pacing of instruction (Bosco, 1984). This study will attempt to assess the importance of presentation sequence in individualized instruction by monitoring student choice of learning modules. It is imperative that instructional designers investigate the qualitative and quantitative nature of interaction in the instructional design of interactive

materials. Formative research and evaluation of interactive products are necessary to improve our understanding of how to individualize instruction and the role of instructional variables such as graphics, speech, motion, and humor in learning.

Statement of the problem

The literature is permeated with widespread concern about the effectiveness of CAI and IVD systems. Evaluative data are needed to demonstrate improvements in student achievement or in reduced instructional time. Additional data are required to assess the effects of the delivery system upon the instructor's and learner's attitudes toward the courseware and to determine if courseware is cost-effective and will provide instructional advantages compared to existing instructional modes. In addition, it is imperative to strive to identify and correlate individual learning styles and personality traits with monitored achievement, sequences, styles and rates of learning. This knowledge will allow courseware designers to develop optimal, individualized coureware and use avaliable resources in a creative, efficient, and effective manner. Additional controlled studies are required to evaluate the effectiveness of integrating the capabilities of technologies such as CAI, IVD, and Compact Disc Read Only Memory (CD-ROM) which converge within a video medium.

IVD courseware is an instructional methodology that is relatively expensive, time consuming to develop, and difficult to use in an optimal manner. The reality of limited finances often means that there is insufficient hardware. The National Task Force on

Educational Technology (1986) suggests that students often work more effectively in groups when using computers. This belief is dependent upon the nature of the task; however, they fail to provide documentary evidence to support the suggestion.

Traditional methods of teaching procedures of infection control that use verbal descriptions to illustrate the consequences of improper procedures cannot provide the dramatic impact which can be realized with interactive video. Interactive video, due to its realism, has a potential to simulate the consequences of these potentially, life-threatening situations.

Educators faced with increasing fiscal constraints must search for more cost-effective and innovative alternatives to traditional instructional methods. The use of IVD technology accrues considerable capital investment and educators must make optimal use of limited resources. The strategy of using these resources individually or in small groups addresses these budgetary considerations and, simultaneously, seeks to optimize the variable of peer group interactivity to enhancing learning. Interactivity, whether it is with courseware, or within a cooperative setting engenders active involvement by the learner(s) (North, 1984).

Jonassen (1985) stated that "the latest technological bandwagon is interactive videodisc.... interactive computer technologies are media in search of designs" (p.21). Jonassen suggested that merging instructional television with CAI represents a technological synthesis of various electronic technologies (computers and television) and of design technologies (instructional design and video design). This

learning environment capitalizes on the advantages of educational television and CAI. It reflects the affective component of television and, simultaneously, overcomes the passive nature of television. This merger with CAI has the potential to allow the learner to individualize the learning experience by matching the learner's style and pace of delivery in an interactive manner.

Fast, random access to voluminous textual and visual databases provided by IVD technology will allow courseware designers to access subject matter in a manner which has not previously been possible (Clark, 1984). This perspective is supported by Cohen (1984), who describes the need for enhanced instructional design models that must be developed to accommodate a limitless variety of interactions with subject matter. In addition, Cohen argues that the interactive and non-linear nature of the videodisc may allow researchers to identify and quantify important learning variables in attempting to optimize learning by employing individualized feedback. Students will be able to used customized courseware based upon the student's apperceived importance of each of these individualized variables.

Purpose of the Study

Videodisc technology has the advantage of providing rapid, random access to a large number of realistic images. When controlled by a microcomputer, the courseware designer can illustrate and simulate life threatening situations and how these situations may be treated. This study makes use of IVD to simulate a common, and potentially life-threatening condition, that is very expensive to the health care

system. An tutorial module of instruction was developed which used interactive, video sequences that illustrate the impact of improper hospital procedures. This study was designed to evaluate the effectiveness of this learning module and the factor of group size upon achievement and productivity ratios. In addition, the study attempts to determine changes in student attitudes toward the use of IVD instruction and to measure long term retention of subject matter.

A student opinionaire was used to determine the students' attitudes toward CAI (Appendix B, p.95). The courseware recorded the sequence used and the time spent in each segment of the courseware. An ex post facto evaluation of the manner and the sequence of use of the courseware modules may contribute to the knowledge base of how students learn. Examination of interactions involving individual preferences for group size and/or the sequences of learning may indicate the role of these instructional variables in the acquisition of knowledge regarding hospital operating procedures.

Hypotheses

The hypotheses tested are as follows:

1. There will be a difference between the mean pretest and mean posttest scores for each treatment group.

2. There will be no difference in mean posttest achievement scores between students working individually, in pairs, or in groups of three students.

3. There will be increases in retention of subject matter as measured by a retention test administered two weeks after completing

the IVD module as compared to the pretest, for all three treatment groups.

4. There will be no difference between the three groups with regard to long term retention of subject matter.

5. There will be no difference in the productivity ratios between the three treatment groups.

6. There will be an improvement in students' attitude toward the use of computers in instruction as a result of exposure to IVD courseware as determined by changes in student opinion after exposure to the CAI module. The subjects would perceive the IVD courseware to be a more efficacious method for teaching than traditional techniques and methods.

7. There will be no difference in time required to complete the IVD module between students working individually or in groups.

Significance of the study

This study was significant in that an attempt was made to verify the efficacy of IVD instruction as summarized by Bosco (1986). An effort was made to identify the importance of the role of peer group interactivity in maximizing student performance and optimizing the utilization of learning resources.

The study sought to capitalize on the affective component of video to improve the student's perception of the value of courseware materials. Based upon teaching experience and advisory activities to curriculum development in the Respiratory Technology Program, the author believes that students perceive several first year courses to

be rather unrelated and irrelevant to the training received in the second year practicum. Consequently, the presentation of a realistic, clinical simulation would enhance the student's perception regarding the value and relevance of the learning materials. This would be demonstrated by a more positive attitudes toward the instructional material.

Limitations and Delimitations of the Study

The study was limited by the lack of a rigorous formative evaluation of the courseware. The evaluation of the courseware consisted of a critical review by two subject matter experts prior to usage by the subjects of the study. The study was limited by a relatively small number of subjects using one specific topic as the module of instruction. A more representative sample would necessarily include several learning modules using IVD courseware over an extended period of time. In addition, the module was studied by the students after they had completed 38 weeks of continuous studies near the end of the program. At the time of the study, the students were mentally exhausted, had considerable demands placed upon their limited time, and were focusing upon final exams.

The study was limited by the lack of a control or comparison group. A study employing a control group would determine a subject's knowledge regarding nosocomial infections at similar times to the groups using IVD. The control group would not receive instruction or have access to information regarding nosocomial infections from textbooks, videotape, or other learning resources.

A questionaire was administered, prior to exposure to the courseware, to assess the student's attitudes toward interactive videodisc courseware. Prior to exposure to IVD, the subjects were unaware of its applications; however, they had been previously exposed to CAI and were instructed to respond by treating CAI and IVD synonymously. The prior exposure to CAI may have sensitized the subjects to alternative methods of instruction and any potential change in attitude scores may have been altered in magnitude due to atypical, pre-exposure scores.

The courseware content was a composite of several related disciplines comprising pathology, bacteriology, respiratory procedures, and pharmacology. Several students have completed advanced training in one or more of the above disciplines. There was a potential for a large variance in pre-requisite knowledge as a significant confounding variable.

The achievement measure was constructed to assess achievement on this module only. The specific nature of the subject matter did not allow normative testing with a larger groups of subjects for comparative purposes.

The results of the study, due to the specific nature of the content of the module, may have limited external validity. The results of the study should not be generalized to programs of study other than the program tested.

DEFINITIONS AND TERMINOLOGY

BASIC - Acronym for Beginners All-purpose Symbolic Instruction Code. A programming language.

Computer-Assisted Instruction (CAI) - is "the direct use of the computer for the facilitation and certification of learning - that is, using the computer to make learning easier and more likely to occur (facilitation), as well as using the computer to create a record, proving that learning has occurred (certification)." Instructional strategies which may be used in CAI include gaming, tutorial, drill and practice, simulations, problem solving, and the Socratic mode Burke (1982, p.16).

Computer-based Education (CBE) or Computer-based Instruction (CBI) - a generic term referring to any instructional strategy which has the basis of using a computer to aid in the delivery or management of instruction.

Computer-based Training (CBT) - an application of Computer-aided instructional programs in industrial, military, or occupational contexts (Kamouri, 1983).

Computer-Managed Learning (CML) - also Computer-Managed Instruction (CMI) a process in which the computer manages the delivery of

instruction. The computer is used to administer tests, grade them and to assist in the development of an instructional prescription for the remediation of any knowledge deficiencies that are discovered.

Feedback - a term used in a generic sense to tell the user if the response is correct or incorrect. Feedback can be one of two types; knowledge of results feedback simply informs the student if the response was correct or incorrect while informational feedback provides information to help facilitate understanding and comprehension of the material.

Generic disc - a videodisc that has been designed to provide an archive of general information that can be accessed by multiple computer instructional programs to teach multiple topics.

Interactive - a term that implies something other than a passive experience. At a minimal level, interactivity would seem to connote the ability of the user to control the way in which a presentation is viewed. The user, in effect, is given the power to alter or change the way in which information is presented. Interaction by the user may take place as a result of a user decision; discrete information from the material being viewed, instruction from the teacher or instructor; or instructions from some auxiliary source materials. Interaction may be via a keyboard, touch panel(s), light pen(s), voice activation, etc. The process is characterized by accuracy and speed of response of the delivery system (Wooley, 1982, p. 149).

Interactive Videodisc (IVD) - a microprocessor controlled videodisc player. See Level II or Level III of Level of Interactivity.

Interface - a shared boundary or the physical connection between the computer and a peripheral device.

Productivity - the average student achievement gains (difference between the pretest and the posttest) divided by the average total learning time expended (in hours) to achieve those gains.

Level of interactivity - the potential for interaction prescribed by the capabilities of videodisc hardware. The level of interactivity can be arbitrarily defined a follows:

Level 1 - interaction which consists of linear play of the disc with the capabilities of freeze frame, frame search, fast and slow motion.

Level 2 - interaction requires as industrial or educational player containing a microprocessor. The videodisc contains a computer program which is loaded into the microprocessor and the user interacts with the videodisc via a keypad.

Level 3 - interaction requires an external computer to supply intelligence to the system. The user interacts with the microcomputer program which, in turn, controls the videodisc player through an interface. The computer program provides textual information to the user, asks questions, evaluates responses, stores student records, and provides remedial branching capabilities on the player.

Peripheral equipment - any unit of equipment distinct from the Central Processing Unit (CPU) which may provide the system with outside communication.

Random Access - pertains to the process of obtaining data from, or placing data into, storage where the time required for such access is independent of the location of the data most recently obtained or placed in storage.

Simulation - a technique that involves creating a model to represent a real-life model.

Software - a set of computer programs, or procedures, which concern the operation of a data processing system.

Turnkey system - a system written and used in such a way that an untrained user can operate the system.

CHAPTER TWO

LITERATURE REVIEW

This chapter contains a review of applications and efficacy of CAI and IVD in education and training. In addition, the role of group interactivity in facilitating learning and the effect of computers upon student attitudes as a potential motivating factor, are reviewed.

Introduction

The literature describing interactive videodisc can be classified into three distinct categories. The first category contains explanations about the nature of interactive video and its applications. A second category contains descriptive information of particular projects and the third group contains evaluations of interactive video as an instructional medium. For the purpose of clarity and of definition, interactive videodisc (IVD) has become synonymous with the term interactive video as a result of the tremenduous instructional capabilities of interactive videodisc, when compared to videotape. Jonassen (1984) suggests that the interactive videodisc has the potential to provide Socratic flexibility of the most creative teacher coupled with high quality graphics and realistic video. The instantaneous branching capabilities provides the possibility of a large variety of sequences adapted to the learner's choice of sequence of presentation or based upon learner preference for visual or verbal learning style, pre-requisite knowledge or tailored to a host of other individualized learning characteristics.

Interactive video is used by agencies within the military, business, government, plus videoarcade games, primary, secondary and

post-secondary education for education, training, marketing, and archival storage of data. Military training applications plus marketing and training applications in the private sector, have been the largest developers and users of interactive video (Clark, 1984). For an overview of the uses and applications of interactive video, see Currier (1983). The educational applications of interactive videodisc are well documented in publications by Bejar (1982), Levin (1983), Clark (1984), Ebner (1984) and Pribble (1985).

Summary Review of Computer-Assisted Instruction

Intelligent/interactive videodisc-based instructional systems evolved from CAI as a result of the natural combination of the power of the computer with the tremenduous storage capacity and rapid random access capability of videodisc technology. A summary statement of the efficacy of CAI is appropriate to introduce the literature pertinent to IVD courseware.

CAI has been used to relieve the monotony of drill and practice on the part of teachers and provide instantaneous feedback to learners, to teach procedural operations or situational responses through simulation, to teach problem solving skills, and to provide knowledge in a tutorial mode (Kearsley, 1983).

Two recent comprehensive reviews of CAI have summarized the contributions and effects of CAI upon instructional effectiveness of this medium. Kearsley (1983) and Robyler (1985) conducted intensive reviews and analysed previous reviews of research and instructional computing published between 1959 and 1985. The two reviews indicated the evaluative studies ranged from formative to summative, qualitative

to quantitative, and descriptive to comparative. Kearsley concluded that most studies were methodologically weak as a result of constraints imposed by realities of the work place. Robyler (1985) made use of a meta-analysis to evaluate the effects of confounding variables such as grade level, subject matter, class size, and student attitudes in a comparison of traditional methods, computer-based instruction, teachers with special education training and instructional television. The general findings of the reviews are summarized below:

1. Computer-based education shows the greatest achievement gains over traditional methods in elementary grades. As the grade level increases, the achievement gain decreases to equivocal or small gains when compared to the traditional method(s).

2. The achievement of the computer-based instruction group is consistently higher than other instructional treatments but, quantitatively, the gains vary from small to moderate.

3. Supplemental CAI seems to produce greater achievement gains than replacement CAI.

4. Computer-based treatments seem to produce a significant reduction in instructional time coupled with a more favorable attitude toward computers.

5. In younger students, mathematics subjects show greater gains than subjects requiring a greater emphasis upon reading skills. In college level students the reverse is true.

6. Younger students tend to learn best from drill and practice types of instructional strategies while college level students tend to show the best achievement gains from tutorial types of strategies.

7. The treatment of instructional television produced higher achievement scores than Computer-based instruction.

8. Recently-published studies evaluating CBI showed higher achievement than earlier studies which compared CBI to traditional methodologies.

9. Studies which used well-defined strategies produced higher achievement gains than studies which made use of instructional activities which might be defined as computer enrichment.

The literature review of IVD usage in computer-based education includes only those studies that used a formative and/or summative evaluation and used a rigorous research design. The majority of the studies compare IVD courseware to traditional instruction. Studies in which the evaluation was primarily of a subjective nature or which used a case history approach were not included. Bloom (1971) discusses the importance of formative and of summative evaluation in courseware design. Formative evaluation relates to the process of developing a program while summative evaluation focuses upon the completed program. Formative evaluation is "the user of systematic evaluation in the process of curriculum construction, teaching and learning for the purpose of improving any of these three processes" (Bloom, 1971, p. 262). Anandam (1981) concluded that many evaluative studies of technology in education fail to include formative evaluation and produce results which make the subsequent summative evaluation more difficult to interpret. Bosco (1986) in reviewing IVD courseware reported that the studies using formative evaluation conducted the formative analysis in a very casual manner. The fundamental (and unanswered) question remains whether the studies

evaluate differences in efficacy of educational technology or is the quality of the courseware the variable that is being measured ?

Henderson (1983) suggests that the talent of the audiovisual designer may constitute the difference in the effectiveness of the media. An example of an inadequate formative study is documented by Huntley and Alessi (1985) as they describe the evaluation of Introduction to Computer Literacy, a commercial product of JAM Productions Inc., which is intended to teach computer literacy to novice computer users. The product was perceived by students to rely excessively upon on-camera narration and the teaching of vocabulary. However, the product did produce effective learning, and was perceived as providing current knowledge and learner control. A rigorous formative evaluation could, conceivably, have provided optimal use of an effective product employing the complete advantage of videodisc technology.

Bosco (1986) conducted an extensive review of formative and summative evaluations of interactive video. Since the majority of users of interactive video are in the military and in the private sector, many of the evaluative studies are inaccessible to the public domain. The general conclusions are communicated at conferences; however, descriptions of research design and conclusions draw from presented data are lacking. A perceived lack of evaluative studies in interactive video results, primarily, from the difficulty in obtaining access to the studies. Bosco (1986) reviewed 28 evaluative reports published (or referred to) from 1981 to 1986. Eight studies were reported in journals, five were available through ERIC, five were presented at conferences and the remainder were proprietary in nature.

Many of the results cited by Bosco (1986) were obtained by personal communication with the courseware producers and users. The most common variables used to measure outcomes were student achievement, user attitude, skill performance, and training time. Comparisons focusing upon training time as the dependent variable must be interpreted with care. While IVD tended to decrease training time there was also an increase in the standard deviation of training time. This finding might be interpreted, favorably, as a beneficial accommodation of individual differences in learning rates. Bosco (1986) noted that the studies reviewed attempted to assess the impact of learner variables such as age, education, prior training, and personality traits. He postulates the lack of impact of these variables upon outcomes would result from the "ceiling effect" commonly observed in competency-based training.

Videodiscs in Corporate Training:

Videodiscs have been used in teaching psychomotor skills involving simulations of actual real world situations. The simulation requires the learner to become an active participant thereby increasing the involvement and the committment of the learner. The realistic images produced by the videodisc enhance the users' sense of realism. Young (1984), cited a study which evaluated the effectiveness of a videodisc simulator compared to a human trainer to teach the operation of complicated communications equipment. The IVD system was as effective as the traditional training method in certification of operators.

Hon (1983) developed a level III IVD system to teach cardiopulmonary resuscitation (CPR), a difficult psychomotor skill. The system included sensory transducers in the mannikin to evaluate the speed and the manner of student response in terms of correct placement of hands, pressure, rhythym etc. The system was self-paced, individualized and the student interaction was via the mannikin, keyboard or light pen. It has served as a stand-alone system to train and to certify CPR skills. Hon reports that a comparative study of the IVD system and traditional lecture revealed a three fold increase in certification using the IVD system. All IVD students took less time than any students in the regular class.

Pribble (1985) relates that American Airline's improved, videodisc-based flight simulators allow the Federal Aviation Administration to re-certify Boeing 727 pilots to fly a Boeing 767 airplane. The first time the pilots actually fly a Boeing 767 is with passengers on board. By inference, this simulation must be perceived as an effective training medium. A similar study (Goldberg, 1983) which used computer-based training revealed that IVD was more effective than classroom, text, slide, or videotape training in office training for American Bell employees. Another study by Duelfer (1983) compared instructor-led courses to IVD in training personnel in the use of a word processor. The IVD group achieved higher post-test results and were reported to have participated more in training than the group using a classroom instructor. Hershberger (1984) evaluated IVD in terms its impact on organizations, on employees, and on trainers. She concluded that IVD stimulated employee involvement in training, encouraged more independence and self-sufficiency; and

increased the esteem and professional status of trainers. Fedewa (1983) reported that a pilot disc used to teach railway safety procedures was favorably received by employees.

Bosco and Wagner (1988) compared the effectiveness of Level III interactive videodisc and classroom videotape for safety instruction of automobile assembly workers. This study compared the efficacy of two different delivery systems which made use of identical course content. Considerable attention was given to develop well-designed training materials to ensure that quality of courseware was controlled to ensure that the delivery vehicles were the measures of comparison. The IVD group had significantly higher achievement scores. Attitude scores and completion times for both groups were similar with results which were slightly favorable for IVD. The subjects were exposed to both learning resource materials and expressed a preference for IVD courseware material. A multiple regression analysis revealed no correlation between age, gender, years of employment, and amount of education on achievement.

Videodiscs in Military Training:

Evaluation of IVD training in the United States Military tends to focus upon the efficiency of the training in reducing training time.

Kimberlin (1982) compared classroom, CAI and IVD simulation for maintenance graining on the HAWK missile control training. The IVD group took half the time to solve repair problems. Ketner (1982) reported similar reductions in training time in a comparison of practice with actual equipment to IVD simulation for maintaining satellite receivers. Manning, Balson, Ebner, and Brooks (1983)

illustrated a significant reduction of time using IVD courseware to teach paramedic and nursing skills while maintaining equivalency in achievement.

Schroeder (1982) compared IVD to programmed learning and to role playing for teaching counselling skills and leadership skills. When tested for understanding, IVD proved superior to both teaching strategies. Holmgren (1980) replicated existing training extension course audiovisual materials (film and slides) on videodisc format. One videodisc contained identical audiovisual materials; a second disc had additional review frames added. All three groups exhibited equivalent achievement indicating that videodisc has no inherent advantage when the audiovisual content on all media are identical. Clearly, the videodisc alone cannot account for the instructional benefits which accrue.

Videodiscs in Educational Institutions:

Eastmond (1984) made use of videodisc technology to assess mathematics skills in primary education for regular and for special education students. This disc delivered an individualized, bilingual, criterion-referenced test which provided a macroscopic and microscopic view of the students' mathematical ability. Use of audio, in addition to textual information, provided a more accurate assessment of the student's mathematical ability than when computer-assisted testing was used. This videodisc eliminated the effects of confounding variables of reading prerequisites and of primary language.

Thorkildsen (1983) used IVD to teach mathematics skills and social skills to emotionally-disturbed and to mentally-retarded

students. It is axiomatic that the need for individualization increases as the severity of the handicapped condition increases. IVD reduces the need for reading skills required by CAI and by traditional instructional methods and served as a superior testing and teaching device. Upon field testing, both groups of students illustrated an ability to learn the subject matter using IVD courseware.

Bunderson, Baillo, Olsen, Lipson, and Fisher (1984) described the use of a videodisc in teaching introductory biology at the college level. This extensive study made use of formative and summative evaluation to assess the effectiveness of the courseware upon producing learning. One group received instruction only by lectures while the IVD group received instruction only by interactive videodisc. Both groups were subjected to identical objective multiple choice exams. One exam was administered as a pre-test, the second as a post-test (one day after instruction) and the third as a retention test (one week later). A subjective, essay exam was given and evaluated according to a key by evaluators which were blind to the experimental treatment. Both treatments produced learning. There was no significant difference in achievement scores on objective tests between the IVD group and the lecture group. On the essay exams, the IVD group showed significant gains in achievement compared to the lecture group. The study times for the IVD group showed a significant reduction. In addition, the productivity ratio for the IVD group was greater than the lecture group. The productivity ratio was defined as the average student achievement gain (points gained on pre/post achievement tests) divided by the average total learning time in hours expended to achieve those gains. The students favorable opinion of

IVD courseware reflects the emotional role of courseware perceived as attractive, appealing, humorous, compelling and challenging. In addition, the medium was perceived by the students as novel, important and powerful, in that events which were not previously available with other media, could be portrayed in an attactive manner.

Mitchell, McNeely, and Chang (1985) used a Level III IVD system to teach the skills of differential white cell counting and blood cell recognition. Half the class used the traditional technique of an instructor in a laboratory session using prepared blood cell specimens with microscopes and microscopic slides. The other half of the class used IVD courseware only and received no personal instruction. The level III system simulated the hardware used to perform differential white cell counts and also provided a large, textual and visual database as a reference guide for the students. The students were tested for their ability to recognize blood cells with the use of 35 mm slides, with images from the videodisc and with microscopic slides on a two-headed microscope. There was no significant difference between the groups with regard to achievement after three weeks of instruction when tested with the aid of 35 mm slides. A ceiling effect may be noted as both groups achieved high scores. The videodisc group did perform significantly better than the traditional group when tested using videodisc images, which may reflect the videodisc groups' familiarity with the medium. The videodisc group learned to recognize the inconsistencies in staining techniques and of image magnification apparent on the test videodisc. When tested using microscopic slides there was no difference in student perfomance between the groups which illustrates that the videodisc group are not disadvantaged by lacking

required skills in using the microscope. The students' perceptions of the videodisc courseware were favorable and included an appreciation of instantaneous feedback, convenient and rapid access to a large reference visual database, clearer detail than provided by the microscope, and an improved efficiency of study time.

Dalton (1986) compared video tape only instruction, CAI and interactive video in teaching motor skills of using shop tools in a Junior High School. The script of the video tape served as the basis of a tutorial CAI lesson. The interactive video group combined the video from the tape with the tutorial from the CAI lesson. The achievement scores ranked from highest to lowest were CAI, interactive video, followed by video alone. All differences were significant. Interactive video had the highest ranking on the attitude scale followed by CAI and video alone. The mean score on the interactive video attitude scale was significantly higher than either CAI or video alone. The lack of benefit in the interactive video group compared to CAI, may be a reflection of the long search times associated with the sequential nature of videotape. It is possible that the students were distracted from the learning task while waiting for the appropriate video segment to be selected.

Gratz (1983) used IVD to teach classroom behavior management techniques. She reported no difference between pretest and posttest means for the IVD coureware. In addition, there was no difference between the posttest means for the IVD group and the group receiving traditional instruction. The subject matter chosen for the study may have been inappropriate to evaluate the effectiveness of the instructional materials. The courseware required the students to

recognize improper behaviors such as cheating. The high pretest scores may reflect the student's innate abilities to recognize such behaviors.

Boen (1983) compared classroom instruction to IVD in couselling students in the techniques of test taking skills. Videodisc instruction provided a significant improvement in achievement.

Glenn (1984) evaluated the use of a self-paced, individualized course in senior high school Introductory Economics using an IVD system. The primary objective of the evaluation was to provide feedback to the developers of the disc (Minnesota Educational Computing Consortium (MECC)). The overall finding indicated a significant difference between pre-test and post-test scores. Unfortunately, the study did not employ a comparison (i.e., non-videodisc group). Student comments reflected the appreciation of self-paced instruction and the interesting nature of the subject matter. Teachers involved in the study viewed the materials to be highly motivating.

In summary, of the 28 studies reviewed by Bosco (1986), 16 reached a conclusion regarding the effectiveness of IVD. Thirteen of the 16 concluded that IVD was effective in producing learning. In three evaluations IVD was not found to be effective. In the remaining 12 studies, no conclusion was drawn. Bosco (1986) relates that a general conclusion would have favored IVD as an effective, instructional medium.

Bosco (1986) assessed reported benefits in the form of higher achievement, reduced learning time, and improved attitudes toward instructional materials as outcome variables. In 61% of the studies

that made inferences based upon statistical comparisons of IVD and traditional methods, there was a significant benefit in favor of IVD. Twenty three evaluations did not apply statistical comparisons. A large majority (96%) of these latter studies favored IVD. Bosco (1986) reported that the studies employing statistical evaluations reported both positive and negative findings while those studies not employing statistical analyses reported positive findings only. Bosco concluded that studies which employed statistical analyses resulted in more conservative conclusions regarding the benefits of using IVD.

Hoko (1986) asks the rhetorical question "What is the value of comparing automated and human instruction?" He suggests that the types of instruction have a myriad of confounding variables and are qualitatively different. Each type possesses advantages, disadvantages, flexibilities and limitations. For instructional technology to advance, it is necessary to ascertain why and how each type is effective. It is incumbent upon educational researchers to strive to understand the factors and principles which operate during effective conventional and automated instruction. Rather than focus upon comparisons of the two instructional types, each should be investigated for its own truths.

Pagliaro (1983) has presented a similar, pragmatic perspective of the role of CAI in teaching pharmacology. He believes that it is unfortunate that CAI has polarized educators into a perspective that CAI is either dehumanizing or a panacea for education. His extensive study suggests that CAI is a sophisticated, poorly understood, neutral technology which educators must learn to apply in a wise and appropriate manner by addressing the needs of individual learners.

The majority of the evidence appears to indicate that IVD courseware is effective in producing learning, has inherent benefits for specialized learning applications and offers an innovative, and improved, technique for instruction (Bosco, 1986). A common, recurrent theme in the literature stresses the need for rigorous formative and summative evaluation of IVD courseware to provide optimal use of this medium. Braden (1985), and many others, believe that IVD hardware is considerably ahead of the design technology to support it. He believes we should clearly discern hardware advantages from instructional advantages and that designers should ensure the medium is being used appropriately.

The large storage capacity and the rapid speed of random access of this new technology has the potential to make available to instructional designers the capability of providing learner interactions with subject matter based upon individualized learner attributes and/or preferred learning styles (Clark, 1984).

Attitude

The current study attempts to measure the change in attitude of subjects resulting from exposure to an IVD lesson. Student attitude is a critical variable to ensure successful learning (Clement, 1981). Success in learning is a function of both effective instruction and a positive attitude toward the learning environment by participants. A fundamental educational objective includes improving student attitude toward subject matter, and learning, in general.

Fishbein and Ajzen (1975) describe attitude as "a learned predisposition to respond in a consistently favorable or unfavorable

manner with respect to a given object" (p. 6). This definition encompasses the following three basic components: (i) attitude is learned, (ii) a response is predisposed by one's attitude, and (iii) attitude is consistently favorable or unfavorable. The assumption that attitude is learned suggests that attitudes may be modified by further learning. Kahle (1984) suggests that attitude may be changed when a person becomes aware that two cognitive elements tend to oppose one another and attempts to reconcile these differences by "changing cognitions or behaviors, changing the importance of cognitions, or adding new cognitions" (Kahle, 1984, p. 11).

Rushinek, Rushinek, and Stutz (1981) demonstrated that students preferred supplemental CAI tutorials to classroom instruction. In addition, computer usage improved the student attitudes toward the use of computers and the student's rating of the instructor. This improvement occurred in spite of perceived inadequacies of access to computers and laboratory assistance.

Skinner (1988) conducted an extensive review of studies to date concerning student and instructor attitudes and perceptions of CAI. The data are encouraging, as most studies indicated that students have positive attitudes prior to using CAI. The initial, positive attitude is enhanced as a consequence of exposure to CAI. In summary, the positive attitude is reflected in a sense of anonymity, the perceived value of immediate, prescriptive feedback, and the highly interactive nature of CAI.

Conversely, Knapper (1978) observed that students resistant to CAI at the beginning of a course demonstrated reduced achievement in

courses employing CAI compared to achievement in courses where traditional instruction was used.

Studies involving student interaction:

There are a limited, but diverse, number of studies which measure the efficacy of computer-assisted instruction delivered to individuals as compared to groups. The studies which follow, make use of microcomputers and mainframe computers; the subjects vary from kindergarten to college seniors. In general, the studies reveal no difference in performance for learners assigned to work individually or those assigned to group settings.

Johnson and Johnson (1985) describe the benefits of cooperative learning and CAI as they wrote:

> How students interact with each other is a neglected aspect of computer assisted instruction. Much training time is devoted to helping teachers arrange appropriate interactions between students and (a) the computer and (b) other curriculum materials, and some time is spent on how teachers should interact with students, but how students should interact with each other while working with a computer is relatively ignored. It should not be. (page 670)

Based upon studies conducted on K-12 students, they concluded that individualistic learning in CAI has the following major limitations: an individualistic learning strategy promotes social isolation, denies the opportunity to produce oral summaries or to provide explanations, prevents social modeling, provides less powerful and less complex

feedback, and is contrary to the student's natural preference for cooperative work.

Carrier and Sales (1987) compared the performance of college juniors working individually and in pairs to learn five concepts delivered by CAI. The study revealed no significant difference between the two groups on the posttest or the retention test. In addition, there was no difference between the posttest mean and the retention test mean administered one week later. Their observations and analysis of audiotapes revealed that students working in pairs chose to review different types of feedback and spent longer inspecting certain screen displays. The study reveals that learning is not facillitated nor hampered by student working in pairs. Computer assisted instruction may have a negative side effect by reducing interaction between students and their teachers as courseware designers seek to enhance the interactivity and stand-alone nature of programs. Johnson (1985) has noted that the instructional use of computers appears synonymous with use by individuals as computer programs appear to be written for a single user. His review concludes that many authors and teachers assume that all CAI activity should be structured individualistically. The basic premise that optimal learning occurs when a student is working independently has been largely unquestioned while the possible use of cooperative and competitive useage of CAI is still unexplored. In most schools, the number of students greatly exceeds the number the computers as evidenced by a 1988, nationwide poll reporting one computer for each 26 students (Computers in Education, April 1988, p.14). This statistic necessitates a cooperative useage of the limited number of

computers. Johnson (1985) compared the efficacy of CAI in groups of four students; the groups were structured in cooperative, competive and individualistic modes. In the cooperative mode, when a single student achieves his/her goal, then all students in that group achieve the common goals. In the competitive learning situation, as one student attains a goal, other students who are linked to that student, do not achieve their goals. In the individualistic mode, the goal achievement of one student is independent of other students. Johnson, et al., (1985) investigated the relative efficacy of cooperative, competitive and individualistic learning on male and female students. Cooperative CAI promoted higher quantity and quality of daily achievement, greater mastery of factual information and greater capability to use mastered factual material in problem solving skills. This group also demonstrated a higher motivation to accomplish learning tasks than did the competitive or individualistic groups. Observations of the students during the learning tasks indicated very little interaction in the competitive and individualistic groups while the cooperative appeared to engaged in frequent exchange of task-related information. Most interactions in the cooperative group were learning oriented while the other groups indulged in socializing and directing unrelated comments to the teacher. An analysis of the sex differnces in the study revealed that boys performed higher on recognition and problem solving questions on the posttest. They were less individualistic, more competitive, perceived more teacher support and perceived the computer as a male domain. Girls liked working with computers more than boys in the cooperative groups while, in the competitive group, the opposite was true.

As educators strive to provide optimal learning environments, the instructor must evaluate personality traits as learner variables while assigning subjects to treatments. Sutter and Reid (1969) administered a problem solving task to male undergraduates and found that students high in sociability and low in test anxiety achieved better in pairs, while students high in test anxiety and low in sociability achieved better while working individually.

Cox and Berger (1985) evaluated problem solving tasks of adolescents with a broad spectrum of abilities who were randomly assigned to work individually, or in groups of two, three, or five students per group. Group efforts significantly reduced the time required for problem solving. Groups of two or three solved problems with greater consistency than groups of five. The authors suggest that when the group are composed of students with a large variance in ability level, the lower level students may not derive the same benefit as students with higher ability.

Lieber and Semmel (1987) investigated the relationship of group size and performance in problem solving activities using CAI in handicapped and nonhandicapped students working individually and in pairs. Each student worked individually, with a handicapped partner and a nonhandicapped partner. Individuals and students working in groups achieved equivalent results on posttests. Handicapped learners achieved higher results on postests when they worked with a partner.

Justen (1988) reported no significant difference in achievement, as measured by pretest-posttest differences, between students working independently or in pairs. Both groups indicated an improved attitude

toward using the drill and practice CAI courseware. The study also revealed a student preference to work individually.

Similar results have been obtained by Sanders (1988). Electrical apprentice students using CAI, showed significant mastery of electrical concepts. Students working in pairs performed as well as students working individually. Students working in pairs performed significantly better on retention tests administered one week later. Student attitude toward the use of computers in instruction, was improved in all students, as a result of exposure to CAI. There was no difference between individuals or pairs with regard to the time required to complete the CAI activities.

Reid, et al., (1973) used CAI to instruct college students in mathematics. This study attempted to correlate the subject's gender and personality traits such as sociability, mathematical aptitude, and anxiety with achievement. The ideal instructional model should address these psychological, situational, social and attitudinal variables. The authors concluded that paired subjects performed as well as subjects working individually. There was no difference in performance or in time required for completion between males and females. In addition, there was no interrelationship between test anxiety, attitude, and gender. Paired students who were rated as low anxious did appear to learn faster but did not demonstrate a significant improvement in achievement.

Johnson (1985) employed an experimental design to evaluate the interaction of gender and handicap on individualistic and paired learning in elementary science classes. Nonhandicapped students had higher levels of achievement than handicapped students however,

handicapped students had greater gains in paired learning situations than in individualistic learning. Males demonstrated higher achievement and more positive attitudes toward science than females. In addition, cooperative learning situations promoted a more positive relationship between gender and handicap level.

No study reviewed to date that used IVD, evaluated the role of working individually compared to groups of two or groups of three subjects. The term interactivity when used to describe IVD, has become synonymous with human-machine interactivity. This study will attempt to assess the integration of human-machine interactivity with peer group interactivity. More specifically, this study attempted to provide additional information on the role of peer group interaction as a potential adjunct to achievement, productivity, and improved attitudes toward instructional courseware.

CHAPTER THREE

METHODS

Population of the study

The entire class of 37 first year students in Respiratory Therapy Technology at an Institute of Technology in Alberta were the subjects of the study. These students had graduated from high school and were enroled in the third semester of a two-year program. The second year of the program consists of a hospital-based, practicum in the hospital which sponsors the student. This practicum is taken just prior to accreditation examinations to achieve certification as a Registered Respiratory Technologist (RRT) by the Canadian Society of Respiratory Technologists. The students ranged in age from 17 to 35 years, and 51% of the students were female. More than 75% of the class had graduated from high school within the past two years.

The IVD module comprised one exercise in a third semester course, in Pathophysiology of the Respiratory System encompassing a total of 42 hours of instruction. The students had prior exposure to the instructional use of computers having completed selected modules of Medical Terminology using Computer-Managed Learning, and Pharmaceutical Arithmetic, a drill and practice CAI component of a Respiratory Pharmacology course. The students were encouraged to participate in the study and signed a document (Appendix F) which indicated that they consented to participate in the study and were aware that they could withdraw from the study at any time without prejudice. In addition, the document authorized the release of their academic record from the Student Record System for the purpose of

making statistical comparisons, plus the document re-affirmed the confidentiality of the academic record. Thirty-four students completed the module. Three withdrew as a result of illness or inability to complete the module.

Description of courseware

A SONY LDP 1000 videodisc player was interfaced to an Apple IIe microcomputer. Each student or student group was presented with textual information on the computer monitor from data previously stored on the computer disk. Video segments and still images from the videodisc were presented to the student on a separate, SONY color monitor under the control of the microcomputer. The videodisc player was connected to the microcomputer by a Prometheus VERSAcard serial interface, which also contained a real-time clock. The connecting cable was a RS-232C, standard Null modem configuration. A videodisc entitled Bacteremia: Diagnosis and Treatment, produced by Miles Pharmaceuticals Inc., was used as the visual database (see Appendix E for a complete description). This disc contains many video segments which illustrate the etiology and pathophysiology of nosocomial infections. The disc was selectively re-purposed by using only those segments of the disc which were necessary to reinforce the script of the courseware. The courseware was written in Applesoft BASIC with computer generated text on a monochrome monitor. The computer program was used primarily to provide instructions, didactic information, and questions to the student. The program evaluated student responses and

provided immediate knowledge of results plus prescriptive and remedial feedback.

The courseware was written to provide a menu-driven, turnkey learning module. The students were presented with several options from a menu which allowed them to study the material in any sequence. Menu choices consisted of an admixture of didactic information, video sequences and/or slides, and diagnostic questions coupled with remediation. Accompanying printed materials described how to start the system and included a suggested sequence of studying the material (see Appendix C for module map). The program recorded the instructional sequence that each group used and the length of time spent in each portion of the module. Performance scores were provided to the students and recorded on floppy disk.

The module was designed to emphasize correct procedures for the respiratory technologist to follow to reduce the risk of transmission of nosocomial infections. It used video segments to illustrate how these infections are transferred, the impact of an infection upon a patient and his family, the impact upon the health care system, and a tutorial segment illustrating the steps in the pathogenesis of nosocomial infections. The module was perceived by the designer to link the first year theoretical courses to the practical training in the hospital. The module was reviewed by two in-house, subject matter specialists prior to student evaluation. The module served as a preliminary study in evaluating the efficacy of IVD courseware in both years of the two year program. The Respiratory Technology program has undertaken the development of substantial amounts of IVD courseware.

Research design

The 37 students were randomly assigned to three groups and the groups randomly assigned to treatments. Group one studied the courseware as individuals, group two worked in pairs of students and group three worked in groups of three students. The courseware integrated subject matter in bacteriology, hospital procedures, and pathology. Prior to instruction, all students were given a written pretest and a opinionaire developed by Pagliaro (1983), which evaluated the students' attitude toward the instructional use of computers on a five point scale based upon a semantic differential. At the end of the module, each individual wrote a posttest and repeated the opinionaire. Selected questions on the final exam in Pathology were used as an indicator of long term retention. The final exam which served as the retention test was administered more than two weeks after the completion of the module. The independent variable was the treatment of working singly, in pairs, or in groups of three. The dependent variables were achievement scores, attitude scores, time required for completion and productivity ratios. An Analysis of Variance (ANOVA) was used to determine significant differences between groups.

This study did not include a control or comparison group. A control group would have been tested at identical times to the IVD groups but would not receive instruction in nosocomial infections nor would they be allowed access to instructional materials. The essential nature of the courseware content precluded the use of a control group. It was decided that the subjects in a control group

would be disadvantaged, potentially, with regard to essential knowledge.

A significance level of alpha = 0.05 was used for the statistical comparisons in the study.

Instruments

Achievement instruments

The achievement instruments consisted of a written test which evaluated the student's knowledge of the demographics of nosocomial infections, the etiology of nosocomial infections, correct procedures to reduce the risk of nosocomial infection, and the interactions of predisposing factors involved in the development of respiratory nosocomial infections (see Appendix A). The test was administered as the pretest and the posttest. The test was graded by an evaluator who was blind to the treatment received by each subject. The grading was performed from a marking key which assessed key words. The retention test consisted of multiple choice questions created from the text used in the pre/post test. The achievement measure was based upon face validity; i.e. the extent to which the instrument "looks like" it measures what it is intended to measure. Face validity concerns judgements about an instrument after it has been constructed and assesses whether potential users of the test liked the items which were employed. Content validity was ensured by the use of a representative sampling of courseware items and by the employment of a sensible method of test construction in consultation with the subject matter experts. Circumstantial evidence for content validity was based

upon a comparison of performance tests before and after the period of training. No attempt to quantify validity by demonstrating covariance with other independent indices was made.

Attitude instruments

Attitudes regarding the use of IVD were evaluated with a questionaire based upon a semantic differential scale first devised by Osborne (1952). The semantic differential provided a direct rating of attitudes on a scale or experiential continuum defined or anchored by bipolar adjectives. The semantic differential scale provided a reliability coefficient of 0.85. This scale is also based upon the concept of face validity. Attitude scores based upon self reporting are the most valid available (Nunnally, 1978); however, they are limited to what the individual knows or is willing to relate about the subject, object, etc., in question. The attitude questionaire was administered at the time of the pretest and again when the posttest was administered. The attitude measure adopted was constructed by Pagliaro (1983), (see Appendix B) and was anchored by bipolar adjectives which assessed student attitudes in the domains of evaluation, anxiety, and familiarity. This 20 item questionaire estimated student attitudes toward the courseware with regard to

(i) evaluation of the courseware; i.e. how did the student's perceive the usefulness or value of the courseware? This domain was sampled with 10 items included as adjective pairs 1, 2, 4, 6, 9, 11, 15, 16, 18, and 19.

(ii) assessment of the degree of anxiety perceived by the student upon exposure to the courseware. Did the courseware engender anxiety in the subjects which might reduce performance on achievement measures? This factor was measured by 5 items included as adjective pairs 3, 7, 10, 13, and 17.

(iii) ascertain the degree of familiarity or understandability that the courseware engendered (items pairs 5, 8, 12, 14, and 20).

For comparative purposes, data from each of the three categories were pooled.

Procedure

The learning station was placed in a quiet area of the Respiratory Laboratory. The learning station consisted of a carroll containing the microcomputer, disk drives, and monitor plus the videodisc monitor. The videodisc player was not visible to the student. The carroll had sufficient room to accommodate three students. The students were not placed on a rigid schedule, but were instructed to complete the module at a convenient time. The students completed the module at lunch time, on breaks, and after class. Each student/student group was given a sealed envelop containing the computer diskette, a module map and instructions, a second envelop, plus a posttest and questionaire for each student. At the end of the module, each student completed the test independently, and sealed the diskette and posttest in the envelop provided. The students were encouraged to write additional comments on the questionaire regarding what they liked and disliked about the module.

The retention test was administered as a portion of the final examination in Pathophysiology a minimum of two weeks after the completion of the module.

CHAPTER FOUR

RESULTS

This chapter contains the experimental data in tabular and graphical form, the results of statistical analysis, and conclusions regarding the hypotheses stated in Chapter one.

Inter-related hypotheses are combined within subsections of this chapter.

Hypotheses 1 through 4: Achievement and Retention

These hypotheses assess the effectiveness of the IVD module in producing learning, and the role of group size in achievement. The hypotheses are repeated below.

Hypothesis 1. There will be a difference between the mean pretest scores and the mean postest scores for each treatment group.

Hypothesis 2. There will be no difference in mean achievement scores between students working individually, in pairs or in groups of three students.

Hypothesis 3. There will be increases in retention of subject matter as measured by a retention test administered two weeks after completing the IVD module as compared to the pretest, for all three treatment groups.

Hypothesis 4. There will be no difference between the three groups with regard to long term retention of subject matter.

The descriptive data for achievement are illustrated in Figure 1 and summarized in Table 1.

Table 1
Achievement Data

	N	Pretest Mean (SD)	Posttest Mean (SD)	Retention Mean (SD)
Individuals	13	18.9 (9.2)	79.0 (7.8)	70.9 (13.0)
Pairs	12	19.2 (9.2)	83.7 (8.5)	79.8 (12.7)
Groups of three	9	18.3 (12.4)	81.6 (14.0)	61.9 (11.6)

A 3x3 analysis of variance (ANOVA) was used to determine if significant differences between measures or treatments existed. The ANOVA data are summarized in Table 2.

Table 2
Two Way ANOVA with Repeated Measures

Source of Variation	Sum of Squares	d.f.	Mean Squares	F
Treatments (A)	939.74	2	469.87	4.70 *
Measures (B)	78272.26	2	39136.13	391.63 *
AB	902.75	4	225.69	2.58
SS within	9293.47	93	99.29	

* Significant difference

There were significant variations between treatments and between measures. A post hoc Scheffe multiple comparison test was applied. The results are summarized in Table 3.

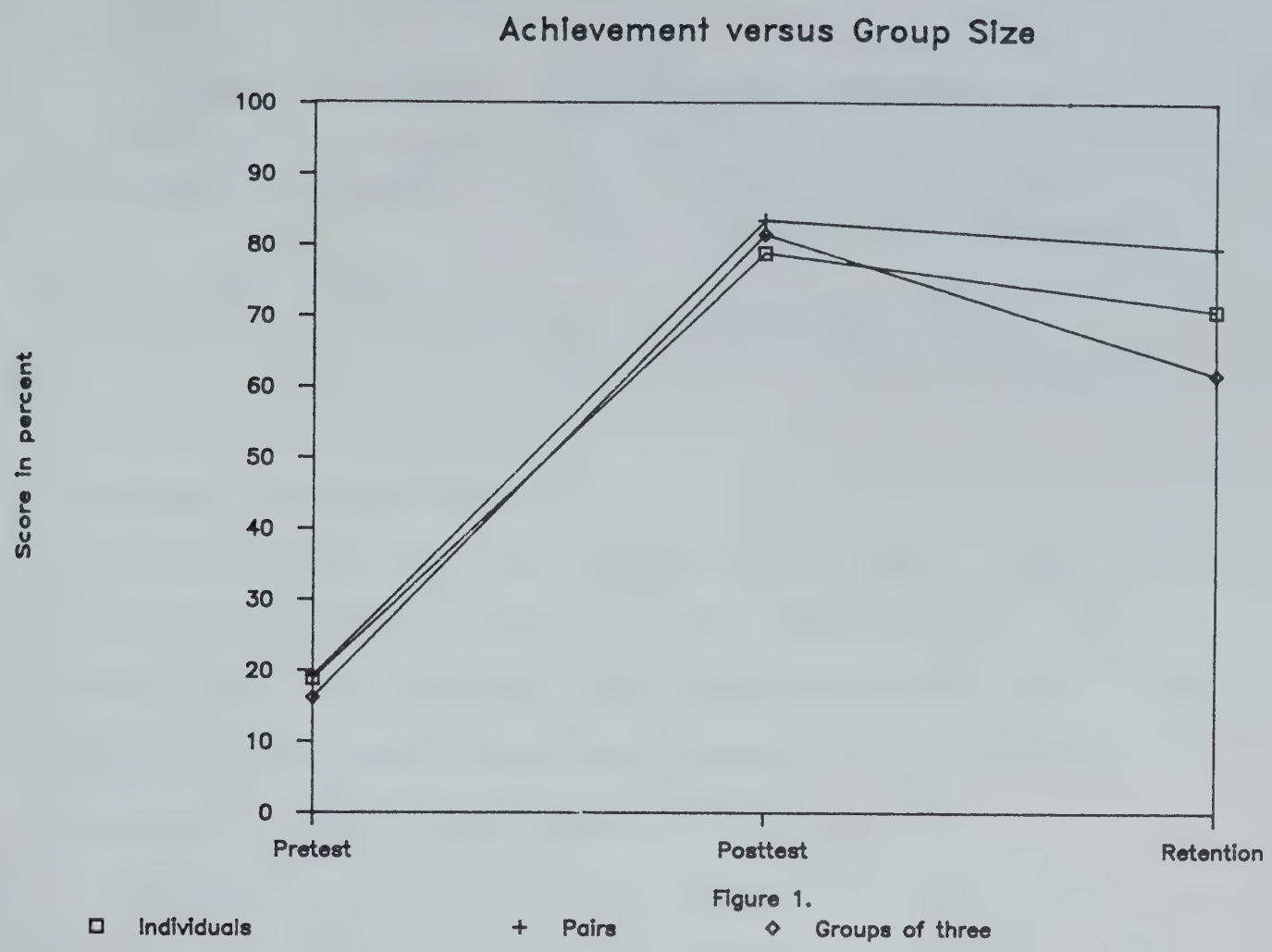
Achievement versus Group Size
Score in percent
100
90
80
70
60
50
40
30
20
10
0
Pretest
Posttest
Retention
Individuals
Pairs
Groups of three

Figure 1.

Table 3
Significant Differences in Achievement (Scheffe Test)

Pretest (all groups)	versus	Posttest (all groups)
	versus	Retention test (all groups)
Retention score (groups of 3)	versus	Posttest score (groups of 3)
	versus	Retention score (pairs)
	versus	Retention score (individuals)

Conclusions: Formal and Informal

Hypothesis one was not rejected. There was a significant difference between the pretest and the posttest means for each treatment group. The IVD module produced increased mean scores on the posttest and the retention test for students in all three groups as illustrated in Table 3. or in groups of three (Table 3).

Hypothesis two was not rejected. Students working individually, in pairs, or in groups of three had equivalent mean posttest scores after IVD instruction (Table 3).

Hypothesis three was not rejected. There were increases in long term retention of subject matter for all three treatment groups after exposure to IVD courseware (Table 3).

Hypothesis four was rejected. Students working in groups of three had lower retention scores than students working individually or in pairs (Table 3).

Hypothesis five: Productivity

There will be no difference between the productivity ratios between the three treatment groups.

The descriptive data for productivity gains for the three treatment groups are illustrated in Figure 2 and summarized in Table 4.

Table 4
Productivity ratio versus group size

	N	Posttest gain Mean (SD)	Retention test gain Mean (SD)
Individuals	13	126.4 (50.8)	110.50 (55.8)
Pairs	12	114.0 (25.7)	109.48 (35.1)
Groups of three	9	97.1 (25.8)	66.82 (22.2)

In this study, productivity is defined as the gain in achievement between the posttest and pretest (or retention test and pretest) divided by the time in hours spent by the student to achieve that gain.

Table 5
Two-Way ANOVA for Productivity

Source of Variation	Sum of Squares	d.f.	Mean Squares	F	
Treatments (A)	1518.8	2	7593.0	4.391	*
Productivity (B)	4178.6	1	4178.6	2.416	
AB	1717.1	2	858.5	0.496	
Within	107198.4	62	1729.2		

* Significant difference

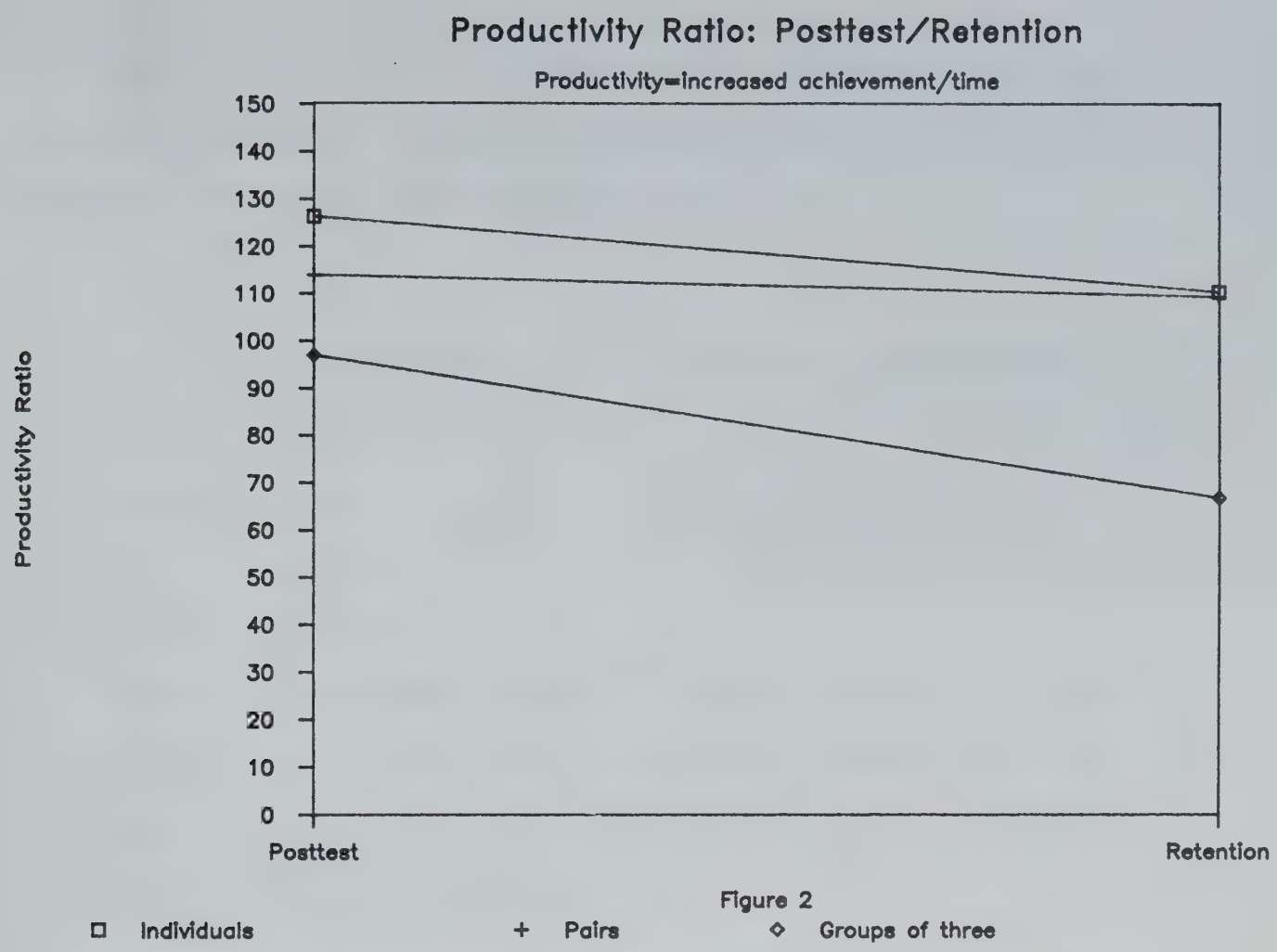
Productivity Ratio: Posttest/Retention
Productivity=increased achievement/time
Productivity Ratio
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Posttest
Retention
Individuals
Pairs
Groups of three

Figure 2

There was significant variation between treatments with regard to productivity ratios. A post hoc Scheffe multiple comparison test was applied. The results are summarized in Table 6.

Table 6
Significant Differences in Productivity (Scheffe Test)

Groups of three	versus	pairs (retention test)
	versus	individuals (retention test)

Conclusions: Formal and informal

Hypothesis five was rejected. Students working in groups of three demonstrated a smaller mean productivity ratio on the retention test when compared to the mean productivity ratio of students working individually, or in pairs (Table 6.)

Hypothesis six: Attitude

There would be an improvement in student attitudes toward the use of computers in instruction as a result of exposure to IVD courseware as determined by changes in student opinion.

For purposes of clarity and definition, the attitudinal scales for evaluation, anxiety, and familiarity, were re-arranged during analysis to reflect an arithmetic increase as the adjective or descriptor becomes more positive. For example, a higher number would be perceived as more highly valued, less anxiety producing, and more familiar.

Evaluation Factor:

The descriptive data for the evaluation scale for the three treatment groups are illustrated in Figure 3 and summarized in Table 7.

Table 7
Changes in Evaluation of IVD courseware versus Group size

	N	Prior to IVD Mean (SD)	After IVD Mean (SD)
Individuals	13	3.9 (0.8)	3.9 (0.9)
Pairs	12	3.4 (0.7)	3.7 (0.7)
Groups of three	9	3.8 (0.9)	3.6 (1.0)

A two-way ANOVA was performed to determine if significant differences in means existed with regard to how the students evaluated the IVD experience(Table 8).

Table 8
Two-way ANOVA for changes in evaluation

Source of Variation	Sum of Squares	d.f.	Mean Squares	F	
Treatments (A)	13.39	2	6.69	9.14	*
IVD (B)	0.09	1	0.09	0.13	
AB	5.33	2	2.70	3.68	
Within	493.77	674	0.732		

* Significant difference

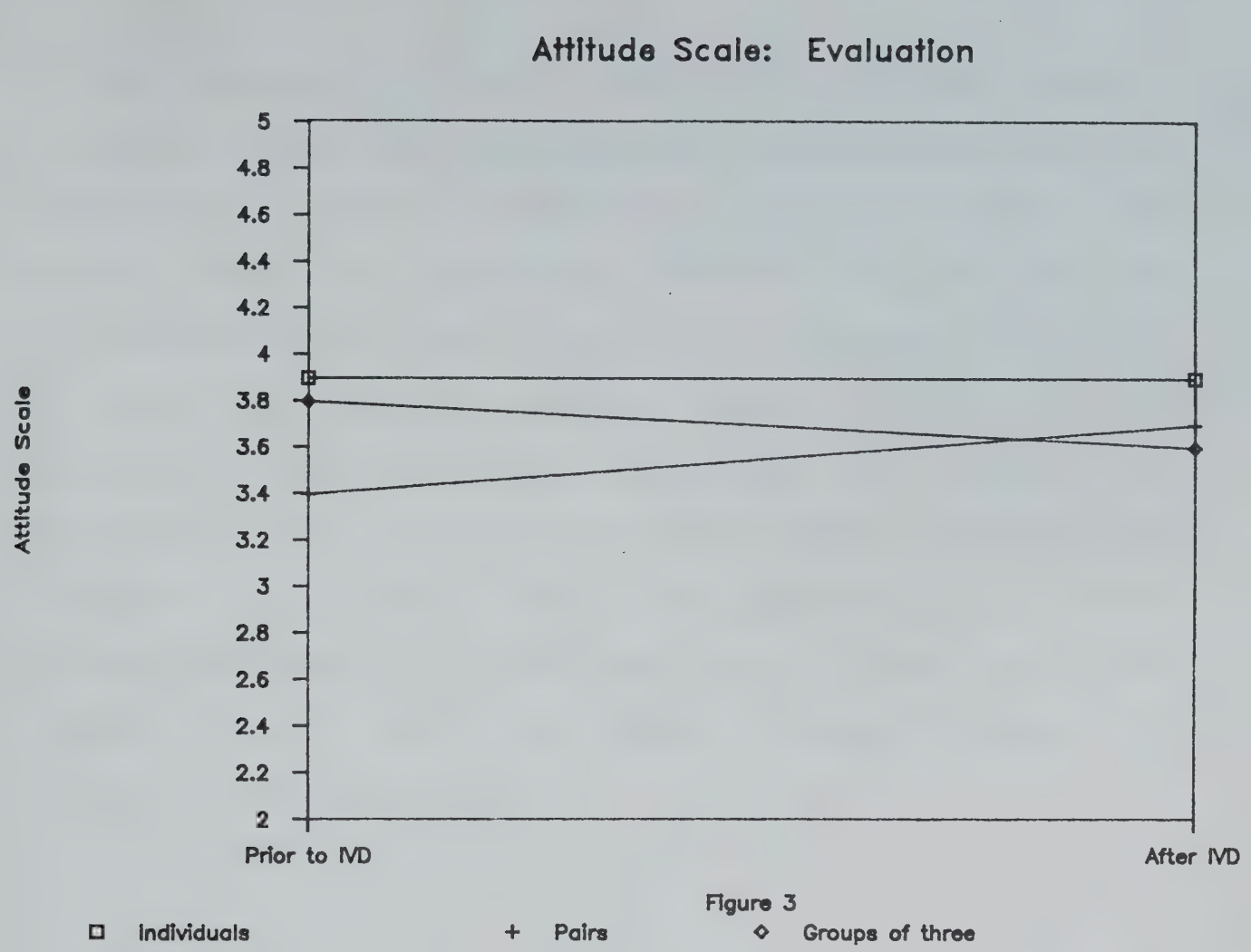
Attitude Scale: Evaluation
Attitude Scale
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
Prior to IVD
After IVD
Individuals
Pairs
Groups of three

Figure 3

As demonstrated in Table 8, there was no significant change in attitudes in any of the three groups as a result of exposure to IVD courseware as measured by differences in the pretest/postest mean scores. There was a significant difference in mean score for evaluation which was related to group size. A post hoc Scheffe test was employed as a multiple comparison of means. Students working in pairs had a significantly lower pre-exposure mean attitude score regarding the value of IVD and CAI than students assigned to work individually or in groups of three. After exposure to IVD, students working individually had a significantly higher attitude regarding the evaluation component than student working in groups of three. The results are summarized in Table 9.

Table 9
Significant differences in Evaluation

	Prior to IVD	
Pairs	versus	Individuals
	versus	Groups of three
	After IVD	
Groups of three	versus	Individuals

Anxiety Factor:

The descriptive data for the anxiety scale for the three treatment groups are illustrated in Figure 4. and summarized in Table 10.

Table 10
Changes in Anxiety toward IVD courseware versus Group size

	N	Prior to IVD Mean	(SD)	After IVD Mean	(SD)
Individuals	13	3.5	(1.0)	4.0	(0.9)
Pairs	12	3.1	(0.7)	3.4	(0.9)
Groups of three	9	3.6	(0.8)	3.6	(1.2)

A two way ANOVA was performed to determine if significant differences existed in the student's opinion with regard to the degree of anxiety that the IVD exposure may have engendered. The ANOVA data are summarized in Table 11.

Table 11
Two-way ANOVA for Changes in Anxiety

Source of Variation	Sum of Squares	d.f.	Mean Squares	F	
Treatments (A)	18.12	2	9.06	21.45	*
IVD (B)	7.95	1	7.95	18.84	*
AB	3.48	2	1.74	4.13	*
Within	284.49	674	0.421		

* Significant difference

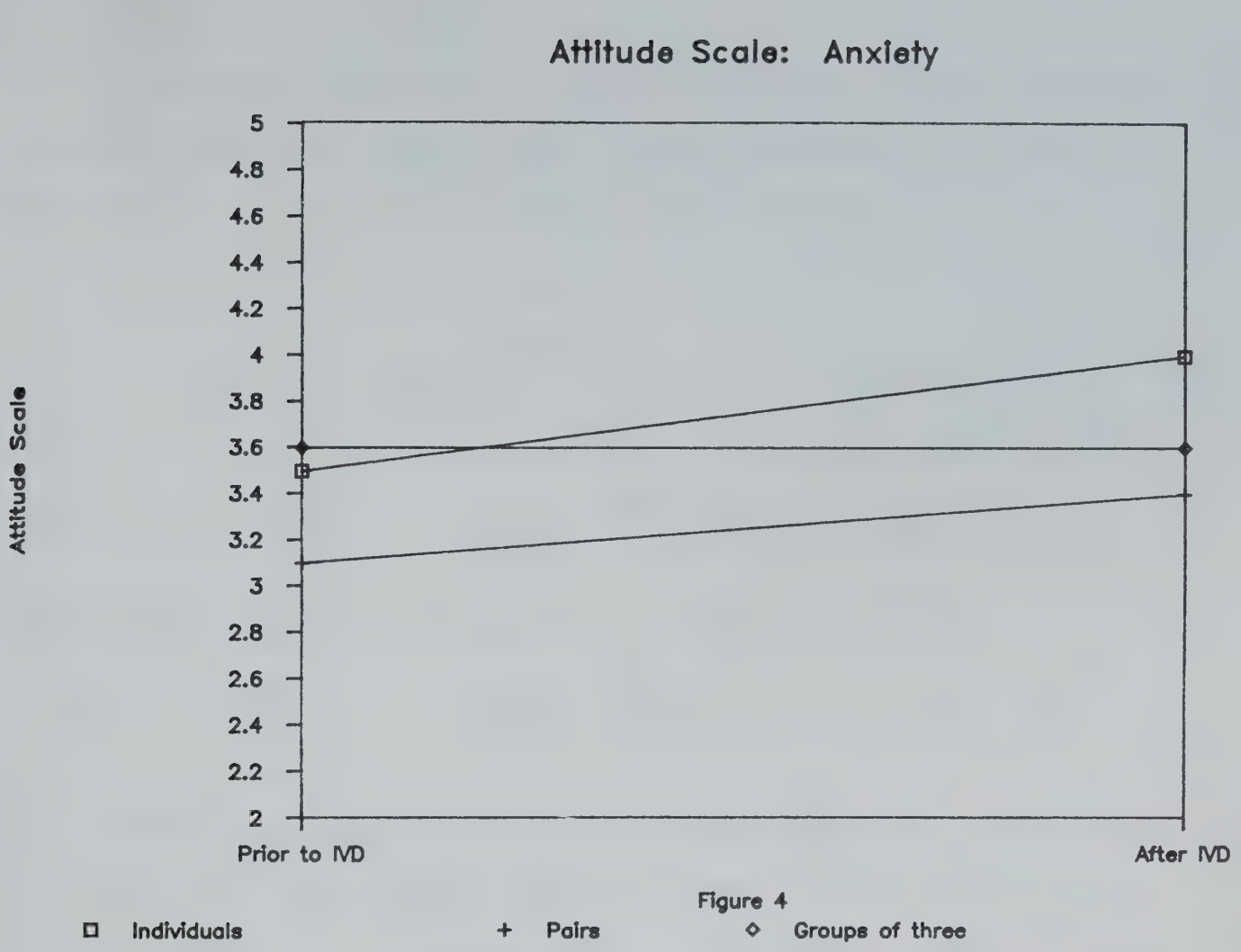
Attitude Scale: Anxiety
Attitude Scale
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
Prior to IVD
After IVD
Individuals
Pairs
Groups of three

Figure 4

A multiple comparison of means using the Scheffe procedure revealed significant interactions. These differences are summarized in Table 12.

Table 12
Significant Differences (Scheffe) in the Anxiety Scale

Pairs (prior to IVD)	versus	Individuals (prior to IVD)
Pairs (prior to IVD)	versus	Groups of three (prior to IVD)
Individuals (prior to IVD)	versus	Individuals (after IVD)
Pairs (prior to IVD)	versus	Pairs (after IVD)
Pairs (after IVD)	versus	Individuals (after IVD)

Subjects assigned to work in pairs had significantly higher mean anxiety levels than subjects assigned to work individually or in group of three prior ot the exposure to the IVD module. Higher anxiety levels were indicated by lower mean scores. Students working alone or in pairs demonstrated a lowered mean score in anxiety as a result of exposure to the IVD module. Students working alone had a lower mean anxiety score than students assigned to work in pairs after the exposure to IVD.

Familiarity factor:

The descriptive data for the degree of familiarity and understandability with the courseware as perceived by the student are illustrated in Figure 5 and summarized in Table 13.

Table 13
Change in Familiarity toward IVD versus Group size

	N	Prior to IVD Mean (SD)	After IVD Mean (SD)
Individuals	13	3.2 (0.9)	3.8 (0.5)
Pairs	12	2.9 (0.7)	3.4 (0.8)
Groups of three	9	3.5 (0.9)	3.8 (0.9)

A two-way ANOVA was performed to determine if there were significant differences with respect to group size and the attitude scale of familiarity. The results are compiled in Table 14.

Table 14
Two-way ANOVA for Changes in Familiarity

Source of Variation	Sum of Squares	d.f.	Mean Squares	F
Treatments (A)	14.75	2	7.38	19.29 *
IVD (B)	19.29	1	19.29	50.48 *
AB	1.75	2	0.88	2.30
Within	257.63	674	0.382	

* Significant difference

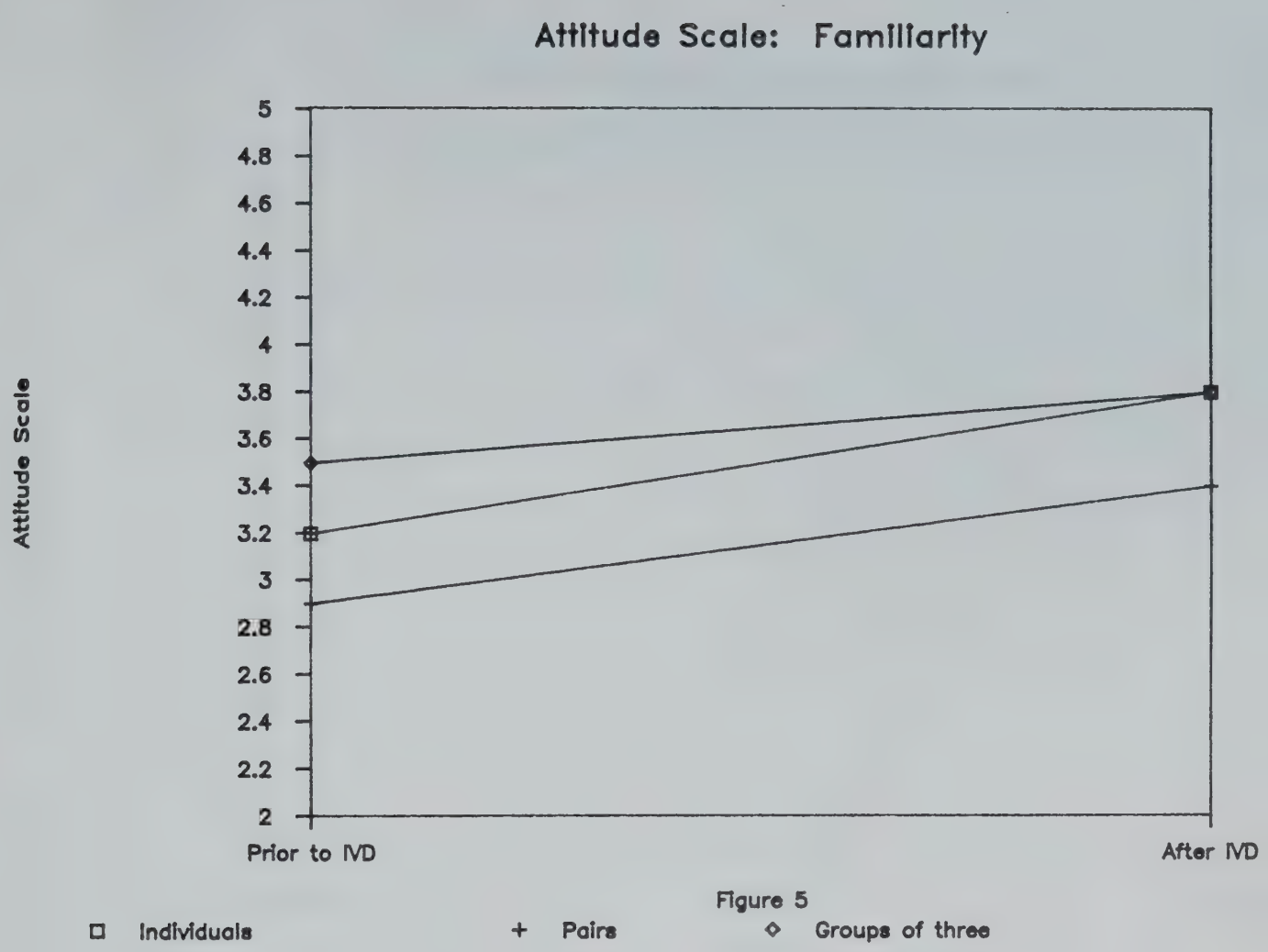
Attitude Scale: Familiarity
Attitude Scale
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
Prior to IVD
After IVD
Individuals
Pairs
Groups of three

Figure 5

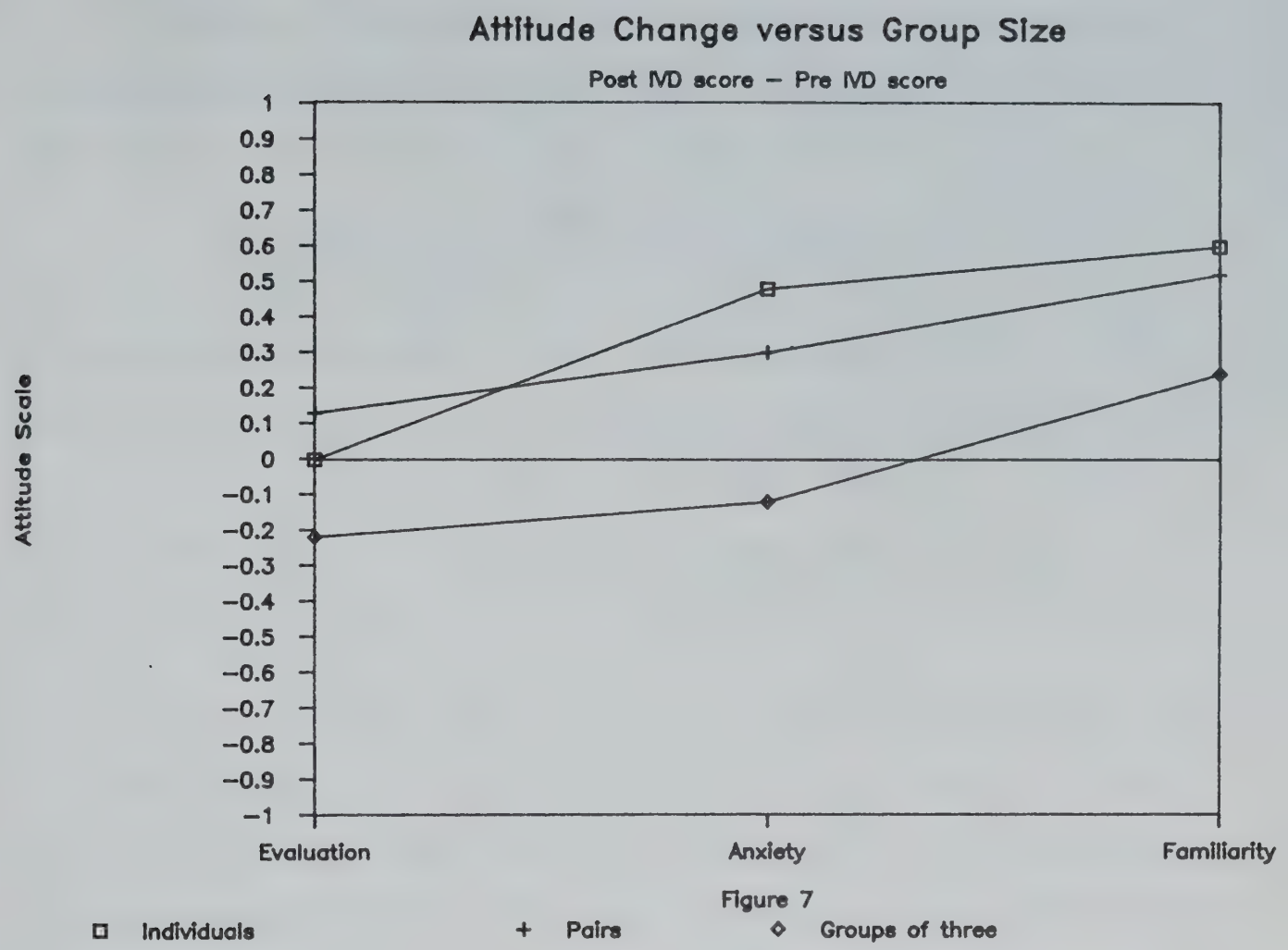
Attitude Change versus Group Size
Post IVD score – Pre IVD score
Attitude Scale
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1
Evaluation
Anxiety
Familiarity
Individuals
Pairs
Groups of three

Figure 7

A multiple comparison of means using the Scheffe procedure revealed significant interactions. These differences are summarized in Table 15.

Table 15
Significant differences in Familiarity Scale

Individuals (prior to IVD)	versus	individuals (after IVD)
Pairs (prior to IVD)	versus	groups of three (prior to IVD)
	versus	individuals (prior to IVD)
	versus	pairs (after IVD)
Pairs (after IVD)	versus	individuals (after IVD)
	versus	groups of three (after IVD)

Subjects working individually and in pairs demonstrated an increase in mean score on the familiarity factor. Students assigned to work in pairs had lower mean scores on the familiarity index before and after exposure to IVD than students assigned to work individually or in groups of three.

Conclusions: formal and informal

Hypothesis six was not rejected. Students demonstrated improved attitudes in the anxiety and familiarity components after exposure to IVD courseware. There was some interaction between group size and change in attitude; students who worked in groups of three did not demonstrate the same improvement in attitude toward the IVD courseware as did the other two groups. Students assigned to work in pairs had reduced attitude scores regarding IVD as compared to students assigned to work individually or in groups of three.

Hypothesis seven: Completion time

There will be no difference in time required for completion of the module between students working individually compared to pairs, or in groups of three students.

The descriptive data for time required for completion of the IVD module for all three groups are and summarized in Table 16.

Table 16
Completion time for IVD courseware

	N	Time in minutes Mean	(SD)
Individuals	13	31.69	(10.67)
Pairs	12	34.84	(8.93)
Groups of three	9	42.67	(8.73)

An ANOVA was performed to determine if there were significant differences between groups. The data are summarized in Table 17.

Table 17
One-way ANOVA for completion time

Source of Variation	Sum of Squares	d.f.	Mean Squares	F
total	5374.4	33		
among	3779.1	2	1889.5	36.72
within	1595.3	31	51.45	

* Significant difference

A multiple comparison of means using the Scheffe procedure revealed significant differences which are summarized in Table 18.

Table 18.
Significant differences in Completion Time

Groups of three	versus	pairs
	versus	individuals

Conclusions: formal and informal

Hypothesis seven was rejected. Students working in groups of three required more time to complete the module than students working individually or those students working in pairs (Table 18).

Subject comments:

Twenty of 34 students took the opportunity to make additional comments about their learning experience. All student comments are included in Appendix D. A summary of the composite adjectives to describe their experience and the enumerative data for those adjectives are included in Table 19.

Table 19
Compiled student perceptions of IVD courseware

WHAT THE STUDENTS LIKED	
Descriptor	Number of students responding (20 of 34)
Use of video	10
Self pacing	5
Interesting	4
Controlling the experience	3
Good supplement to lectures	3
Perceived as useful	2
Perceived as easy	2
Enjoyable	2
Fast	2
Using the computer	2
Flexible timing	2
Informative	2
Effective	2
Perceived as valuable	1
Good use of my time	1

WHAT THE STUDENTS DID NOT LIKE	
Descriptor	Number of student responding
Did not like working with others	4
Timing of presentation of the module was poor	4

Chapter Summary

This chapter presented the data in graphical and tabular form, plus the statistical analysis of achievement measures, productivity, completion time, and attitudes changes toward IVD courseware. Subjective comments on the courseware were compiled. The results indicate some interaction between group size and achievement, productivity, time required for completion, and attitude. Students assigned to work in groups of three demonstrated lower achievement measures, smaller productivity ratios, increased time required for completion of exercises, and lower attitudinal scores than their peers assigned to work either individually or in pairs. The following chapter contains a detailed discussion of the results.

CHAPTER FIVE

DISCUSSION

This chapter summarizes the results of the study and compares these results to the findings of other, related studies. This chapter also includes suggestions for additional studies to identify and evaluate learning variables in continuing attempts to optimize learning.

Summary of results

As summarized in Tables 1 and 2, the IVD module produced significant learning in all subject groups, as measured by the difference between pretest and posttest scores and pretest/retention test scores. The data in Table 3 demonstrate that assigning students to work in groups of three, resulted in lower retention scores than students working individually or in pairs. The students in groups of three had a significant reduction in performance as measured by lower retention scores. There was no reduction in achievement from posttest scores to retention scores (2 weeks later) for pairs or individuals (Table 3). In addition, students working in groups of three had significantly lower productivity ratios compared to students working in pairs or as individuals (Table 6). Exposure to IVD courseware did not improve the student's attitudes toward learning

materials in all three indices of evaluation, anxiety, and familiarity. The interaction of IVD and group size did reveal that students who worked alone evaluated the module more positively than students who worked in groups of three. Students working in pairs or as individuals, demonstrated a reduction in anxiety (Table 12) and an improvement in familiarity or understanding (Table 15) as a result of exposure to IVD courseware. Students working in groups of three did not demonstrate a similar reduction in anxiety nor improved familiarity. Students working in pairs had a significantly higher level of anxiety and a significantly lower familiarity score before and after IVD than the students working as individuals or subjects working in groups of three. Table 16 reveals that students working in groups of three required a greater amount of time to complete the IVD module. A subjective evaluation provided by solicited comments from the students were, generally, positive and were summarized in Table 19.

The gains in achievement and productivity for students working in groups of three were significantly reduced. If educators continue to be presented with budgetary constraints, then a compromise between reduced academic performance and cost of courseware delivery poses a dilemma for educators who desire to optimize learning and, simultaneously, make effective use of limited resources. Educators must, in some manner, balance the impact of sub-optimal qualitative use of learning resource materials, with the increased quantitative demand for courseware to be delivered with limited resources.

This study provides additional data to the general body of knowledge defining the effectiveness of IVD using CAI. Studies which compare CAI to traditional instruction are useful only in a general way and tend not to add a great deal to our knowledge of specific computer-related variables which enhance or impede learning. Bosco (1986) conducted an extensive review of IVD courseware and the general assessment was that IVD accounted for effective learning, coupled with higher achievement, reduced learning time and improved student attitude when compared to other modes of instruction. The results of this study would support the general conclusions of the review conducted by Bosco. Most current instructional programs operate on the basis of a small amount of information about the student. Most programs are incapable of taking into account many learner traits and transient psychological, situational, social, and attitudinal variables (Bosco, 1986). This study provides additional confirmation to studies performed by Reid (1973), Sanders (1988), and Justen (1988) that there is little difference in the achievement of students assigned to work individually or in pairs, and there appears little reason to limit usage to the individual student. In fact, the accomplishment of many tasks might require, or may be facilitated by, interaction and cooperation of two individuals working together.

Analysis of results: Attitudes

Kulik (1986), in an extensive review of adult computer-based instruction, concluded that students at the secondary school level and above who are taught using computers have a more positive attitude

toward computers than those students taught using conventional techniques. Skinner (1988) in his review of student attitudes toward the use of CAI has concluded that, in general, students in higher education have a positive attitude toward the use of computers in support of learning. Students who begin with a neutral or mildly favorable attitude toward the use of computers prior to instruction, frequently demonstrate an additional improvement in attitude after exposure to CAI. This study is consistent with Skinner's (1988) result as all pretest scores on the indices of evaluation, anxiety, and familiarity were positive. All students in this study had previously been exposured to CAI and CML which had been used to supplement their instruction. This study demonstrated a reduction in student anxieties and an increase in the familiarity index for students working alone or in pairs. The finding that students working in groups of three showed no improvement in attitude after IVD and had lowered scores in attitude compared to pairs or individuals suggests an interaction between group size and attitude. Pagliaro (1983) reported an increase in the familiarity index after exposure to CAI courseware and interpreted this increased understanding as a measure of content validity. This study demonstrated similar results and concurred with Pagliaro's findings and perspective that CAI (and IVD) should be regarded as an effective, but essentially, neutral technology. IVD has the potential to interact within the educational milieu in either a positive or negative manner. To make this interaction a positive experience, requires wise and appropriate instructional design. Due to the potential variance in the measuring

instrument, it is probably inappropriate to attempt to equate subjective, positive student evaluations of IVD with positive performance or attitude.

Analysis of results: Achievement

Clark (1983), in an extensive review of research on learning from media, emphasized that the content of the learning vehicle is the important factor in influencing achievement. His literature review suggests that there is a slight advantage for newer learning media over more conventional instructional vehicles; however, this advantage is small and subject to the influence of confounding, and largely uncontrolled, variables.

The majority of studies reviewed by Justen (1988) suggest that students have a preference for individual CAI especially when the students feel self-conscious within the context of group CAI. However, his results demonstrated no difference in achievement in CAI using a drill and practice strategy in learning mathematics. This study also revealed no difference in performance between students working alone or in pairs. Reid, et. al. (1973), demonstrated that performance in mathematics was influenced by the interaction of learner attributes working in pairs to a greater degree than the effect of group size per se. Anxiety level, gender, aptitude toward mathematics, and sociability appeared to exert important influences upon achievement and it is incumbent upon the instructional designer to make available to the learner the opportunity to take advantage of the learner's strengths and minimize the effects of the learner's

weaknesses. This study concurred with the results of Carrier and Sales (1987) who reported that the pairing of students did not facilitate nor compromise performance. However, students working in pairs did take longer to complete the module, chose different types of feedback and viewed certain screen displays longer.

Cox and Berger (1985) used microcomputers to administer several problem-solving tasks to adolescent students working individually, in pairs, groups of three and groups of five. Students working in groups demonstrated a progressive decrease in the time required for problem solving over successive tasks. Individuals did not demonstrate a similar reduction in time for problem solving. The study demonstrated a curvilinear relationship between group size and effective problem solving. Groups of two or three tended to solve problems with greater consistency than teams of five and solved more problems than students working individually. These results, together with the current study, suggest an optimization of instructional strategy which adopts an optimum group size. The optimum group size must be assessed for each learning activity and is a composite of learning task and individualized learner attributes. The results of this study suggest that an instructional strategy employing groups of three in an IVD tutorial may not be an efficient use of learning time. The factor of size, per se, is probably less important than the quality and quantity of group interaction and the nature of the specific learning task.

Thomin and Fink (1963) reviewed 31 studies which investigated the effects of group size in a variety of learning situations. The group size varied from 2 to 20 subjects and the learning situations involved

memory recall, problem solving and judgement skills. Their review revealed that it is not uncommon to find a curvilinear relationship between group size and performance measuring recall and problem solving capability. The optimum group size appeared to be task dependent. The general conclusions were that group size had no effect upon problem solving tasks or memory tasks. In tasks involving judgement, there was a reduced speed in making judgements as the group size increased; however, the quality of the judgement was improved.

Bunderson, et. al., (1984) used the measure of productivity to assess learning efficiency. Productivity is the measure of achievement gain divided by time spent to achieve the gains in performance. This composite measure uses achievement and learning time required to assess the efficiency of learning. Productivity is increased when (i) achievement is increased and/or (ii) time is reduced. Conversely, productivity is reduced when (i) achievement is reduced and/or (ii) time is increased. This study revealed that students working in groups of three had lowered productivity compared to students working in pairs or as individuals. The lowered productivity demonstrated by students working in groups of three resulted from the increased length of time required to complete the module, and the reduced achievement on both the posttest and the retention test.

Students assigned to work in groups of three demonstrated lowered productivity ratios and reduced achievement levels compared to other groups (Table 3 and Table 6). An analysis that focused upon making efficient use of limited learning resources would note that 32

minutes (approximately) were required for one student working individually to complete the IVD lesson. Two students could be trained in 35 minutes (17.5 minutes per student), and three students could be trained in 43 minutes (14 minutes per student). An appeal to one's pragmatic sense to make efficient use of learning resources would require that a compromise be made between an acceptable degree of lowered achievement and the greater number of students who could be trained per unit time.

Analysis of results: Time for completion.

This study is consistent with the results of Carrier and Sales (1987) who reported that students working in pairs took longer to complete a CAI lesson than students working independently. The paired students had more group interaction, but did not show improved performance as a result of pairing. This study reported increased time for completion as the group size increased with no difference in achievement between pairs or individuals.

Practical Implications

This study has demonstrated that students assigned to work in groups of three are disadvantaged with regard to achievement and productivity. Similarly, they do not demonstrate the same positive attitude toward the use of CAI and IVD when compared to students working in pairs or as individuals. The results of this study indicate that it may be inappropriate to use groups of three when IVD is used in a tutorial mode. A different CAI strategy such as problem solving,

gaming, or a simulation requiring a team effort might be appropriate for a group of three. The student interaction in a group of three would possibly be a function of the personality types in the assigned groups. Personal observation of the students studying the module revealed that in several instances, one individual in the group of three tended to react passively while working on the module. By comparison, I did not observe a subject studying as a member of a pair, reacting in a similar passive fashion. It is incumbent that the instructional designer have a specific task for each group member to engage the learners in active (and interactive) learning. For optimum benefit, this interactivity must include intra-group interactivity and human-machine interactivity.

Casual Observations:

Analysis of the time spent in each segment of the module and the sequence used by each group indicated that students, in general, progress through the module in a sequential fashion in spite of the opportunity to view any segment in any sequence. Only two groups took the opportunity to view the materials in a non-linear manner. This supports the conclusions of Gray (1987) and Steinberg (1977) that instructional designers tend to place excess value upon the necessity for user control over sequence of presentation. Gray demonstrated that control of sequencing increased comprehension, but had no effect upon retention. In addition, sequence control resulted in a more negative attitude toward CAI. Steinberg (1977) concluded that students do not care about control over the sequence of instructional

materials. It was interesting to note that students who were assigned to work in groups completed the module at an earlier date than students who worked individually.

An analysis of the student answers for question number 5 on the pretest indicated that 12 percent of the students were able to recall that the most effective procedure to reduce nosocomial infections is for hospital personnel to wash their hands between patient contacts. The IVD learning module had this axiom as a basic, recurrent theme. By using realistic video sequences and case simulations, the learners were made aware of the importance of this procedure in dramatic fashion, and the dire consequences which result if these procedures are not followed. All students answered this question correctly on both the posttest and the retention test. It was interesting to learn that this principle was presented to the students in a lecture and discussion period approximately 8 weeks prior to the use of the IVD module. However, the students did not recognize the importance of this procedure until presented with the realistic video sequences from the videodisc. The potential cost savings to the health care system are enormous provided the subjects transfer the principles of infection control to operating procedures.

Suggestion for future research

Prior to the random assigning of students to groups, a questionaire determined the student's preference for working alone or in groups, and their apperceived degree of test anxiety. A common

statement was the desire to work independently; however, the research design assigned subjects at random to one of three groups. A better research design appraoch might be to address these individual preferences. It is mandatory that instructional designers begin to address the unique nature of learners. Learner traits must be identified and courseware must be sufficiently flexible in order to accommodate these learner traits plus any transient psychological, situational, social, and attitudinal variables. A similar study which identified the subject's individual preferences for individual work or group work prior to random assignment to groups may, potentially, optimize the learning environment. For example, those who prefer to work in groups would be assigned to pairs; while those who prefer to work alone would be assigned to work individually. Learner attributes such as sociability, gender, degree of test anxiety, degree of computer anxiety, and other attributes could be identified and the assignment of subjects to pairs could be optimized. To intentionally inhibit learning would infringe upon the limits of ethical behavior; however, it would be interesting to determine possible interactions which might result from a repeated measures research design which assigned subjects who prefer to work alone to a group learning situation and conversely, persons who prefer to work in groups would be assigned to work individually. A subsequent learning module would measure their achievement using their preferred style. cross-over

In this particular topic of study, by conducting additional longitudinal studies, it would be interesting to determine if the theoretical concepts learned in the module were transferred to

appropriate operating procedures in the hospital environment. This transfer of procedural knowledge could then be documented with a corresponding reduction in the incidence of nosocomial infections.

A more comprehensive IVD course conducted in an effort to corroborate these findings, would increase the external validity of this preliminary study.

Optimization of IVD courseware must address the unique nature of learners and encompass peer group interactivity coupled with human-machine interactivity. Additional studies involving interactions between IVD and group size should consider learner attributes in addition to the task or CAI strategy to be employed.

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APPENDIX A

POSTTEST

NAME _____

NOSOCOMIAL INFECTIONS: ETIOLOGY AND TREATMENT

1. Define bacteremia.

2. Define nosocomial infection.

3. What TWO criteria must be met in order to be classified as a nosocomial infection ?

4. Define what is meant by the term colonization.

5. What single procedure, which the respiratory therapist (and other hospital personnel) can apply, is the most important in reducing the risk of transfering infections from one patient to another ?

6. Within 1 %, what percentage of hospitalized patients develop nosocomial infection ?

7. Within 5 %, what percentage of nosocomial infections involve the lower respiratory tract ?

8. What is the mortality rate (in percentage) associated with nosocomial infections involving the respiratory tract ?
(within 5 %)

9. What is the mortality rate (in percentage) associated with nosocomial infections involving the respiratory tract when the causative organism is Pseudomonas aeruginosa ?
(within 5 %)

10. In Canada, approximately what is the estimated number of annual deaths due, directly or indirectly, to nosocomial infections ?
(within 500)

11. Name the most common source of Pseudomonas organisms in the hospital.

12. Name five SPECIFIC compromising or predisposing factors which favor the development of nosocomial infections. (drug therapy is excluded)

13. Name the five steps, in the proper order, which characterize the pathogenesis or development of nosocomial pneumonia.

14. Name two specific classes of drugs which will compromise or reduce the patient's resistance to nosocomial pneumonias.

APPENDIX B

STUDENT OPINIONAIRE

Student i.d. Number _____ Date _____

I am attempting to obtain a quantitative assessment of your attitude regarding computer-assisted instruction (including interactive videodisc) and the role of computers in instruction. Please circle the answer which most appropriately describes your CURRENT attitudes toward computer-assisted instruction. Each scale is continuous from one descriptor to its opposite. Use the value of 3 to indicate a neutral response.

Computer-assisted instruction using interactive videodisc is:

1.	Boring	1	2	3	4	5	Interesting
2.	Valuable	1	2	3	4	5	Worthless
3.	Disturbing	1	2	3	4	5	Not disturbing
4.	Appropriate for teaching	1	2	3	4	5	Not appropriate for teaching
5.	Simple	1	2	3	4	5	Complex
6.	Bad	1	2	3	4	5	Good
7.	Calm	1	2	3	4	5	Anxious
8.	Mysterious	1	2	3	4	5	Understandable
9.	Unpleasant	1	2	3	4	5	Pleasant
10.	Tense	1	2	3	4	5	Relaxed

11.	Fair	1	2	3	4	5	Unfair
12.	Usual	1	2	3	4	5	Unusual
13.	Restful	1	2	3	4	5	Nervous
14.	Confusing	1	2	3	4	5	Clear
15.	Useful	1	2	3	4	5	Useless
16.	Negative	1	2	3	4	5	Positive
17.	Apprehensive	1	2	3	4	5	Non-apprehensive
18.	Ineffective	1	2	3	4	5	Effective
19.	Quick	1	2	3	4	5	Slow
20.	Unfamiliar	1	2	3	4	5	Familiar

Using a similar numeric scale please circle the rating which most accurately describes your responses.

1. I would describe the amount of test anxiety that I have before exams as

   high 1 2 3 4 5 low

2. I prefer to work alone to study or to complete assignments.

   agree 1 2 3 4 5 disagree

3. I consider myself to have an outgoing personality.

   agree 1 2 3 4 5 disagree

4. I would describe myself as highly motivated.

   agree 1 2 3 4 5 disagree

5. I would describe myself as being highly independent.

   agree 1 2 3 4 5 disagree

APPENDIX C

DIRECTIONS FOR VIDEODISC MODULE

Procedure to start:

1. Insert the floppy disk for your group in the left hand drive of the Apple //e.
2. Turn on the power bar.

When you have finished, SIGN OFF THE SYSTEM USING MENU CHOICE NUMBER 4. The results of the questions asked during the module will be stored but will NOT be used for credit toward successful completion of the module. When you have completed the module, open the sealed envelop assigned to you, complete the post test quiz and seal the results and the diskette in the envelope provided AND TURN OFF THE POWER BAR.

GENERAL INSTRUCTIONS:

To correct an answer, use the left arrow [<--] key to move the flashing cursor back to the mistake, type over the mistake, and enter with the [Return] key.

Ensure that the [Caps Lock] key is down and that you differentiate between the following characters:

1 and l (el)

0 (zero) and O (oh)

If the module hangs up or stops and the keyboard is locked, you can recover by simultaneously depressing the CONTROL, OPEN APPLE and RESET keys. Perform this procedure ONLY when the keyboard is locked.

Instructions and hints: 1. All information will be provided to you on the computer screen or on the videodisc monitor.

2. A 'beep' on the computer will be a prompt for you to direct your attention to the computer screen.

3. The instructional segments can be chosen from a menu according to your wishes; however, I would recommend that you follow the sequence in numerical order. You may repeat any segment as often as you wish when you are presented with the main menu.

4. I would encourage you to take notes if you so desire.

5. Check off the menu choices on the module map as you complete each choice to ensure that you complete each section.

MODULE MAP

MAIN MENU

DEFINITION & STATISTICS	CASE HISTORY & SIMULATION	PATHOGENESIS OF NOSOCOMIAL INFECTIONS
1. Definitions		1. Source of organisms.
2. Mortality & morbidity		2. Transmission of organisms.
3. Effects of Nosocomial Infections		3. Colonization of upper resp tract.
		4. Entry to lower tract.
		5. Overcoming anti-bacterial defenses.

A. Frequency distribution by site

B. Mortality & cost by site

C. Endemic & Epidemic statisitics

D. Causative organisms

The double headed arrow indicates that you move up or dowm within the menu structure as indicated by the interconnecting arrows.

APPENDIX D

STUDENT COMMENTS ON IVD COURSEWARE

- the explanations were excellent.
- very clear.
- it was nice to be able to go at your own speed to fully understand each section.
- it wasn't very time consuming
- the visual simulations were interesting.
- easy to manipulate
- not great to do it during lab time
- if it had been earlier in the year but I felt I could not put the time and effort into it that may be required due to the timing.
- I feel this type of learning activity is very effective for supportive or reinforcement learning. But I feel that person-person teaching is more stimulating.
- as a supplement it is useful but must not replace "regular" teaching.
- I like the video segments, speed of delivery, the fact that you had control and the review questions so that you can guage your understanding. However, I would have liked more than 1 chance at the questions before the conputer responded with the correct answer. More review questions would have been helpful as well. Overall- a very pleasant way of learning particularly boring material. This would be a great way to learn diseases !

- Visuals good! made you finish something you started. Helps with people who don't or can't always sit and study for long periods of time.
- I liked the module, it is very useful and makes a somewhat boring subject interesting.
- I didn't think there was much information but that kept me interested because it wasn't too long.
- I like working by myself because you can work at your own speed. You are also forced to do all the work yourself instead of relying upon your partner(s). The only thing I didn't like (which is quite minor) is that I had to do this on my own time (I'm busy studying for a major exam)
- This is a very effective way of teaching.
- It was an interesting method to learning. I was a little hesitant in the beginning because I'm not used to computers.
- It is definitely different method of learning. Maybe it's newness stimulates a greater interest in finding out what it's all about.
- the video slides were interesting and information stays with you longer.
- liked the video segments
- It was a good idea, just that it was bad timing in the year with final exams so close.
- I liked it !
- Thought it was fine, simple, understandable.
- I liked doing the work on your own time, and at your own speed. Good support to classroom instruction. I didn't like

not being able to stop half way through and finish the rest of it later.

- I feel that if I had more exposure to computers I would enjoy it more. I get a little frustrated because I don't know how to use them and it takes me too much time. I know that it can be useful and valuable, however.
- I enjoyed the videos but I did not like working in a group. You always felt rushed therefore, I learned nothing. I think alone all the anxiety would have been out of it, and it could have been very enjoyable.
- I thought the videodisc was very interesting to watch. It was easy and fast.
- the videodisc was interesting and informative. I don't like working with people, nothing personal, I just like to work alone so that I can go a lot faster. I like the use of the computer. This exercise was nice but came at a bad time as I needed much exam study time.

APPENDIX E

Bacteremia: Diagnosis and Prevention (Copyright, 1982) is the initial videodisc in a 9-part series on Nosocomial Infections. It was developed by Miles Pharmaceuticals under the editorial direction of Dr. Richard E. Dixon, Hahnemann University , Philadelphia, Pa. with Dr. R.A. Garibaldi, University of Connecticut and Dr. D.A. Goldman, Children's Hospital Medical Center, Boston, Mass.

This videodisc is a Level II videodisc designed to operate on Pioneer videodisc players. The videodisc operates from a menu displaying the table of contents. Menu choices include the following:

1. Instructions on the operation of the player
2. Bacteremia: Etiology and Epidemiology
3. Patient Case Simulation
4. Cannula Insertion
5. Collection of I.V. specimens
6. Laboratory Culture and Analysis of I.V. Specimens
7. References: Charts, Graphs, and Illustrations.

The videodisc is available from Miles Pharmaceuticals, Division of Miles Laboratories, Inc. 400 Morgan Lane, West Haven, Conn 06516

APPENDIX F

RELEASE OF STUDENT RECORD INFORMATION

I, _____ hereby give my permission to the Northern Alberta Institute of Technology to release my weighted grade point average for the 1987/88 term and my grades in MLT 161 and BSS 251 to those researchers evaluating interactive videodisc courseware. The information will remain confidential and individual marks will be used only for statistical comparisons. Individual student identities and marks will not be revealed. I agree to participate in the study and I understand that I may withdraw my participation from the study at any time.

_____ _____

Date Signature

B45954